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**Operational Survey - VFR
Heliport Approaches and
Departures**

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Final Report

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16. Abstract <p>This report documents a field survey about helicopter performance and operational considerations pertaining to heliport design issues. Helicopter operators, manufacturers' flight instructors, and FAA Technical Center pilots were surveyed in an attempt to relate their actual VFR helicopter operating techniques to heliport airspace requirements.</p> <p>The opinions and information obtained from the 88 pilots surveyed from around the country represent 17 types of helicopter models operating at a broad spectrum of density altitudes. The specific data has been summarized and characterized so as to be representative of the civil helicopter industry. Results show a wide variation in opinion, even among pilots flying the same aircraft models, about what constitutes safe straight approach and departure distances, adequate acceleration distances, and realistic climb angles.</p> <p>Pilots opinions indicate that they can climb at higher angles than are indicated by the profiles presented in "Helicopter Physical and Performance Data," DOT/FAA/RD-90-3, in order to clear close-in obstacles. However, in flying these higher angles, pilots are flying through portions of the height/velocity envelope that the FAA and the manufacturers recommend be avoided.</p> <p>During the formal review process a number of FAA officials concluded that in many instances the pilots perceived performance capabilities that exceeded the aircrafts' performance capabilities. Also, of concern were instances when the aircraft could perform the maneuver, but the steep climb/descent angles needed would substantially increase the risk of an accident.</p> <p>This is one of a series of five reports that address helicopter performance profiles and their relationship to the VFR protected imaginary surfaces of approaches and departures at heliports. The other four reports are</p> <ol style="list-style-type: none"> 1) Helicopter Physical and Performance Data, DOT/FAA/RD-90/3, 2) Heliport VFR Airspace Design Based on Helicopter Performance, DOT/FAA/RD-90/4, 3) Rotorcraft Acceleration and Climb Performance Model, DOT/FAA/RD-90/6, and 4) Helicopter Rejected Takeoff Airspace Requirements, DOT/FAA/RD-90/7 - - - 			
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PREFACE

The research effort reported herein was managed by the Federal Aviation Administration, Vertical Flight Program Office (ARD-30), under contract to Systems Control Technology, Inc. (SCT). The operational survey and the analysis of the survey results were performed by Raymond A. Syms and Associates, 1705 Bayley Court, Bridgewater, NJ, 08807, under subcontract to SCT. Except for section 7.0, all portions of this report were prepared by Raymond A. Syms and Associates. Section 7.0 was prepared by SCT using data obtained in the operational survey.

This document was reviewed by interested parties as part of normal document processing. Significant concern occurs in the area of confined area performance where some pilot perceptions regarding climb capabilities appear to exceed the capabilities of their helicopters, particularly at the more demanding weights, altitudes, and temperatures. This concern was also shared by the interviewer.

The authors believe that the personal interview process and the use of actual field examples kept the data collection as exact as possible. "Real life" obstacle clearance situations were presented to the pilots and operators. Reasonably exact field methods were used to measure the slopes of the obstacle clearance planes represented by these "real life" situations. Even under these operationally familiar conditions, it was evident that the perceptions of attainable slopes varied significantly from subject to subject. It was recognized that some of the responses have been overstated, however, these were left in the report for completeness and to keep the pilot/operator input intact.



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1.0 INTRODUCTION

In support of the Federal Aviation Administration's desire to maximize the safe use of helicopters at heliports, alternatives to current heliport design criteria and airspace utilization guidelines are being studied. These new concepts are proposed in the document "Heliport VFR Airspace Design Based on Helicopter Performance," DOT/FAA/RD-90/4 developed by Systems Control Technology, Inc. (SCT) under FAA contract DTFA01-87-C-00014. An issue of particular interest to this subject involves understanding how the slope of the heliport approach and departure surfaces affects VFR operations. To fully understand and address the issue, an in-depth knowledge of current operating procedures used by the industry is essential.

This report analyzes current helicopter operating procedures in an attempt to identify those techniques that could influence the development and use of heliports. Previous work efforts have centered on certification data. These data, while accurate, may not incorporate the flight procedures of many helicopter operators and therefore, an effort has been made to supplement them with subjectively derived field data.

This effort relies heavily upon observations and interviews with helicopter operators and FAA helicopter principal operations inspectors as a cross-check of the previously developed certification information. The results of the field data collection, while subjective, indicate a perceived difference between actual operating procedures and those assumed in the flight profiles presented in "Helicopter Physical and Performance Data," DOT/FAA/RD-90/3. The principle reason for this difference is that pilots sometimes fly through portions of the height-velocity curve that FAA and the manufacturers recommend be avoided.

2.0 STUDY OBJECTIVES AND PURPOSE

In order to provide for the safe and orderly growth of the U.S. system of heliports, appropriate design standards may need to be updated. Analysis of present-day operational realities of the helicopter industry can provide additional data to enable heliport design standards to reflect safe, efficient and acceptable standards.

One could argue that the "ideal" helicopter would be one which could, at maximum gross weight, under the most demanding operating conditions, safely land and take off vertically. This would greatly simplify heliport design, since any area large enough to safely accept the rotor disc and overall length of the helicopter could potentially be a heliport.

One could conversely argue that the "ideal" heliport is one which would never require helicopter loads to be reduced or helicopter performance to be taxed. This facility would have to accommodate the minimum performance of the weakest helicopter at maximum gross weight and under the most adverse atmospheric conditions of high altitude and high temperatures (high density altitude). Such a heliport would require 2,000 feet of protected groundspace and have very shallow, obstruction-free, approach and departure planes. Unfortunately, these site requirements would be very difficult to meet in the typical areas where helicopter demand is the highest, especially in urban areas.

Neither of these "ideal" scenarios appears practical in light of operational realities. A flexible airspace system is therefore needed to match the physical size constraints of the heliport with the operational characteristics and capabilities of the helicopter.

While helicopter performance information based on helicopter certification data is available, the use of that data without verification that it reflects the true picture of helicopter performance could be misleading. Any assumptions built on that data may then prove to be invalid.

With this in mind, two primary study objectives were formulated:

- o to gather relevant data concerning "real world" helicopter approaches and departures, under differing conditions, and
- o to meaningfully characterize these field data observations such that generalized standards, applicable to the entire industry, can be developed.

3.0 METHODOLOGY AND SCOPE

This study relies upon operational information and data from the helicopter industry at large. As such, there are only two primary sources of information: certification data and survey information. The previous effort to establish a helicopter and heliport classification system was based mostly on certification data from the manufacturers. Unfortunately, that effort did not consider many of the current operating practices used in the industry. Thus, the thrust of this study is the survey of helicopter operators and the collection of field data relating to the actual airspace and operational usage of heliports in a VFR environment.

The scope of this effort was necessarily broad and encompassed two general areas: a field survey and data analysis. Development of the field survey was preceded by the identification of data parameters. The data analysis, which forms the central portion of this study, was undertaken using survey results input into a database to aid in the correlation of data. The analysis was supplemented by informed professional judgment.

3.1 SURVEY INSTRUMENT

Pilots from three sources were surveyed:

	<u>Total</u>
o Helicopter Manufacturers (model surveys)	9
o Helicopter Operators	
- Part 91 - not for hire	15
- Part 91 - offshore	1
- Part 91/135 - combination	6
- Part 133 - aerial crane only	1
- Part 135 - for hire	24
- Part 135 - offshore	11
- EMS only	11
- Public Safety - fire, police, etc.	8
o FAA Technical Center Pilots	2
TOTAL	<u>88</u>

This broad resource base would ensure that a variety of operational requirements, experiences, and opinions would be collected. Surveys were also administered to pilots flying in a variety of operational and climatic environments throughout the CONUS. Heliport operators were presented with a modified version of the survey to obtain additional insight into airspace issues. Lastly, FAA helicopter principal operations inspectors were informally interviewed to provide their perspective on issues.

Special attention was given to the development of a survey method that would incorporate helicopter operational experience as it exists in

the industry. Prior to the start of the field effort, it was realized that few helicopter operators not directly involved with heliport design and development issues would be familiar with heliport obstacle slope criteria. Applications of numerical designations of obstacle slopes, to include percentag , ratios, or angular degrees, are not normally a part of the helicopter operator's knowledge. For this reason real-life graphic representations, both in the interview sheets and "visual representations," were used extensively in the program. Copies of the field survey forms and diagrams are presented in section 4.

During the beginning of the field work, the helicopter operator's unfamiliarity with numerical descriptions of helicopter departure climb and approach angles also became very apparent. The use of examples found at the operators' own heliports, and application of common items presenting obstacles (i.e., cars, trucks, fences, trees, etc.) better explained the use of imaginary obstacle clearance planes to those interviewed. By using a known set of values, approximate approach and departure angle information was obtained.

3.2 DATA ANALYSIS

The field data survey information was entered into a database. The database was configured to provide comparisons of helicopters in categories of single engine, twin engine, and by specific helicopter models. The takeoff procedures recommended by the helicopter manufacturers as well as those practiced in the field dictated that two separate types of departure procedures be evaluated.

The database developed for this project contains 88 records of information, 1 record for each operator in the survey. Each record contains 33 data fields representing the responses of the operators to the various questions in the survey. The database was used to produce histograms and projected aircraft departure profiles to graphically present significant survey responses. Pilot responses were also correlated to certification materials as an additional frame of reference.

4.0 DATA COLLECTION

As mentioned earlier, the data collection effort focused on two primary sources: published data (secondary source) and field surveys (see figures 1 through 4). Each of these data sources are discussed below.

4.1 PUBLISHED DATA

Reference was made to applicable FAA regulatory documents, more specifically Title 14 of the Code of Federal Regulations (14 CFR) and the appropriate FAA advisory circulars (AC's). Those examined for this study effort included:

Code of Federal Regulations

14 CFR Part 77, Objects Affecting Navigable Airspace: Subpart C, Obstruction Standards; Paragraph 77.29, Airport Imaginary Surfaces for Heliports.

14 CFR Part 27, Airworthiness Standards: Normal Category Rotorcraft, Subpart B, Flight Performance.

14 CFR Part 29, Airworthiness Standards: Transport Category Rotorcraft, Subpart B, Flight Performance.

Advisory Circulars

A/C 61-13B "Basic Helicopter Handbook," 1978.

A/C 150/5390-2 "Heliport Design," dated 1/4/88.

A/C 150/5300-13 "Airports Design," dated 9/29/89.

A/C 150/5300-4B "Utility Airports," dated 7/3/85. (for information purposes only)

A/C 27-1 "Certification of Normal Category Rotorcraft," August 29, 1985.

A/C 29-2a "Certification of Transport Category Rotorcraft," September 16, 1987.

Other

In addition, information supplied by the prime contractor was used in developing this report. This information included draft technical reports, aircraft flight manuals, and other FAA reference information.

The draft technical reports were "Heliport VFR Airspace Design Based On Helicopter Performance" and "Helicopter Physical and Performance

Date _____ Operator _____ Location _____
 Name _____ Title _____ () _____

1. Operator estimate of any safety concerns, i.e., any type or classification of approaches and takeoffs that are not as safe as others. (in or out of H.V., ect.)

Is this affected by temp or Gross Weight? _____

2. Any type of approach/departures that you feel should not be used?

3. What are your preferred take-off procedures? Does it vary with the temperature and gross weight?

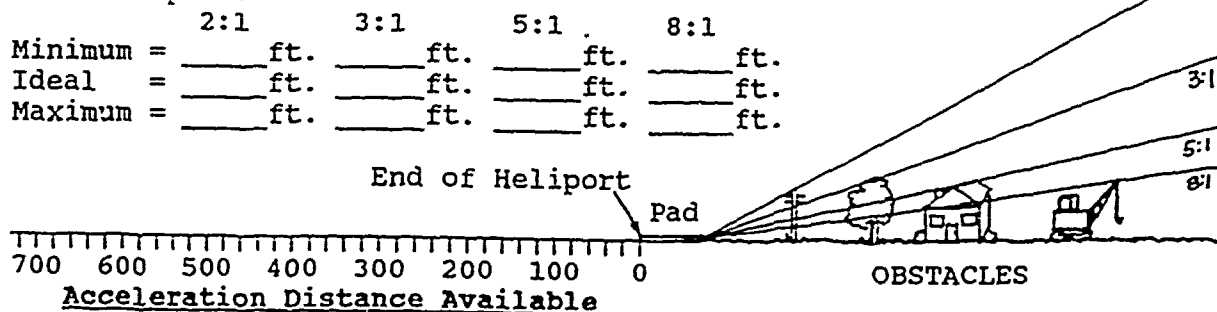
Landing Procedures? _____

4. Does this afford you less or more capability in the use of of a confined heliport?

5. At what point (in feet from takeoff point) of your takeoff profile would you feel comfortable in turning off a straight departure path?

6. What would you consider to be the comfortable minimum of feet that a helicopter needs to be on a straight approach to a heliport?

7. If the availability of "acceleration distance" prior to having to climb out over obstacle(s) assists your performance; please indicate on the drawing what you feel would be the minimum, ideal, and practical maximum of acceleration distance you would like to have at a heliport.



COMMENTS? _____

FIGURE 1 OPERATOR INTERVIEW SHEET

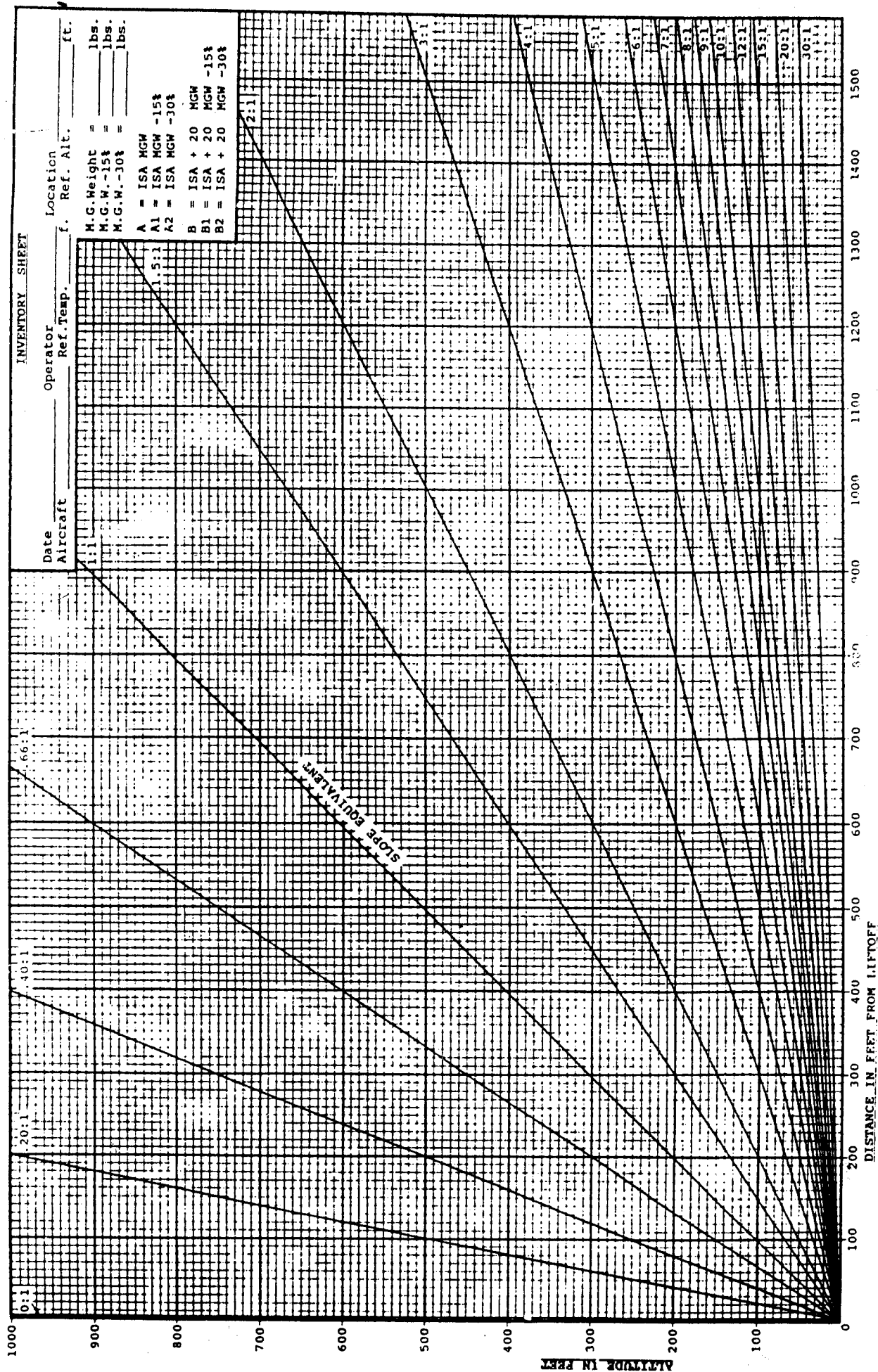


FIGURE 2 INVENTORY SHEET

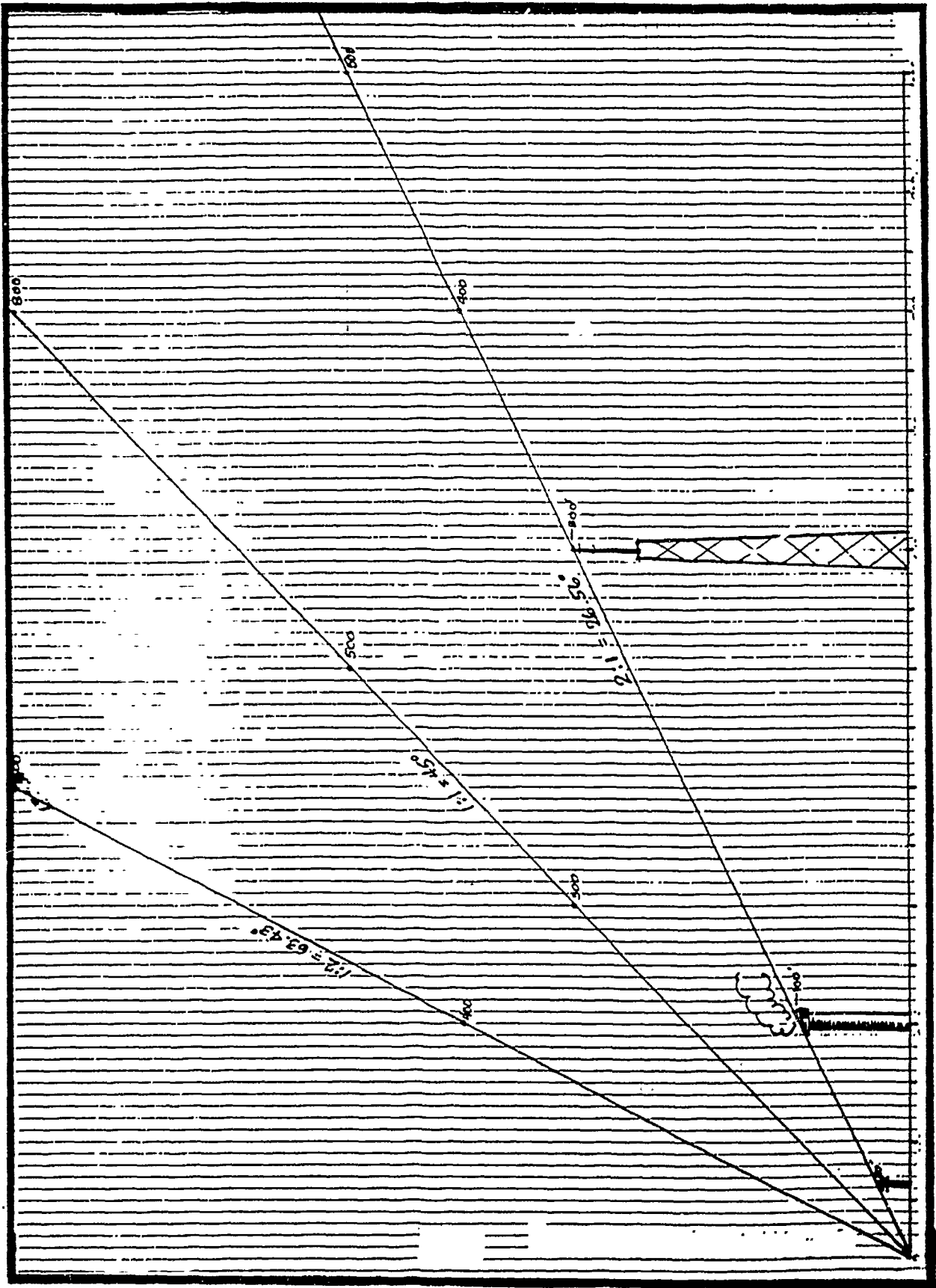


FIGURE 3 CONFINED OPERATIONS DEPICTION #1

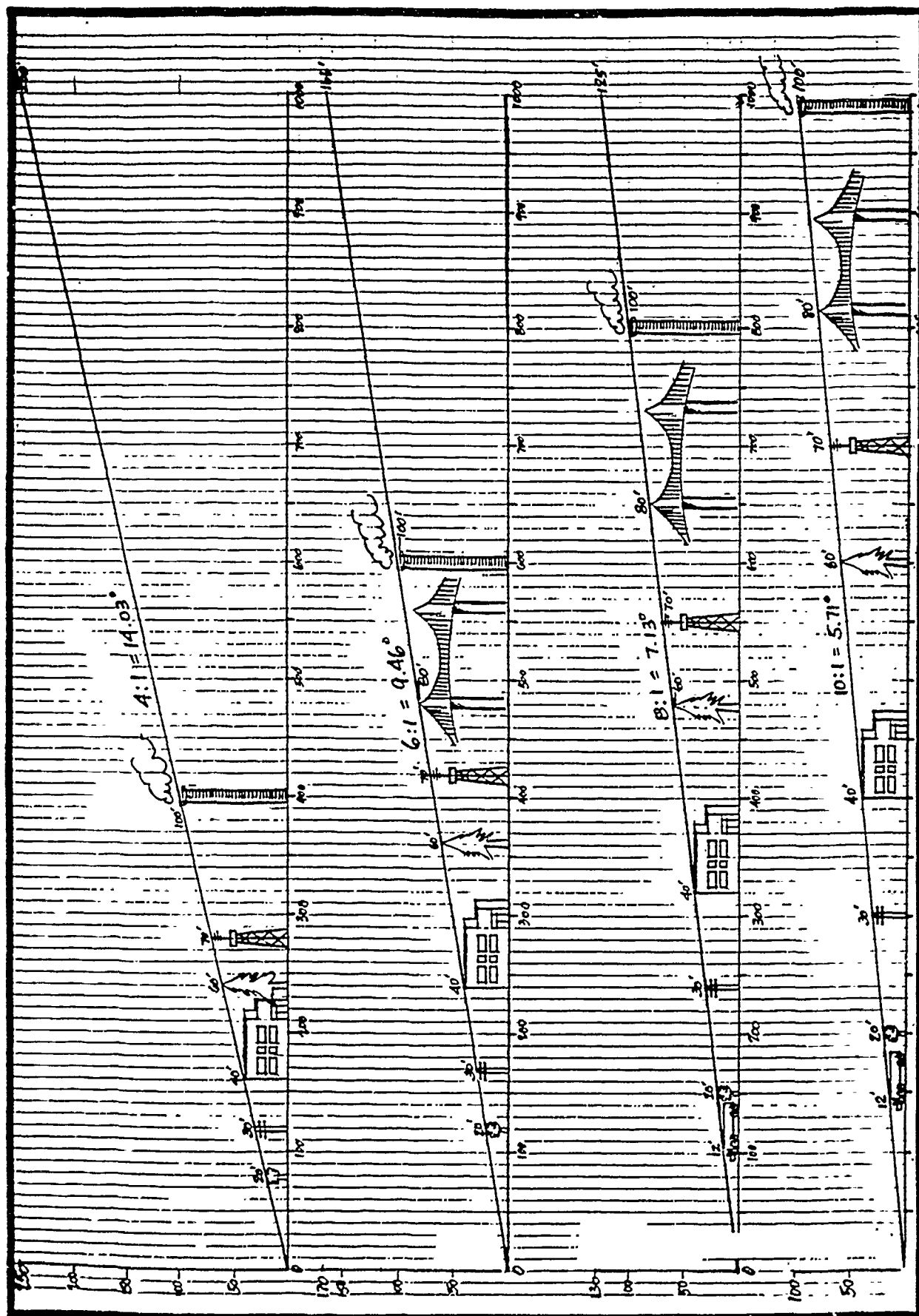


FIGURE 4 CONFINED OPERATIONS DEPICTION #2

Data." The departure profiles contained in the second document were examined and, while this examination was not exhaustive, there were no areas where accuracy of the performance data was in question.

The documents also noted the lack of confined area performance information in the helicopter flight manuals. Examination of normal category helicopter flight manuals confirmed this fact. One notable exception was the MBB B0105CBS flight manual, which contained a wealth of confined heliport performance information.

All of the pilots interviewed relied almost exclusively upon personal experience and knowledge rather than reference to flight manual performance data for determining helicopter performance capabilities. Several management personnel from different operators added that they would not feel comfortable with a captain who did not know his/her aircraft well enough to make such judgments.

NOTE: During the survey, a large number of pilots (35 percent), when asked about departure performance for their helicopters, made verbal reference to the aircraft flight manual as being their source for such information, even though such information was indeed not in their respective manuals. A request to the pilot to provide specific information generally led to 10-15 minutes of the pilot leafing through the flight manual and not finding the departure performance material. It was apparent that this was not a procedure followed often, if ever, to determine aircraft performance capabilities. Without exception, the pilot's final answer was offering the use of the out-of-ground effect hover ceiling chart to determine confined area takeoff capability. Hover in-ground effect charts were often referred to for departure capability from an unrestricted takeoff location.

4.2 SURVEY INFORMATION

The first task in the work program was to develop a list of industry representatives to be contacted. An essential part of this study was linked to the takeoff and landing procedures taught by various helicopter manufacturers. Due to the importance of this baseline data, the study schedule included visits to all major helicopter factory schools. The major manufacturers of commercial helicopters flown in the U.S. are represented in the following list:

Helicopter Manufacturers

Aerospatiale Helicopter Corp (U.S. Facility)
2701 Forum Drive
Grand Prairie, TX 75053

Agusta Aviation Corporation
3050 Red Lion Road
Philadelphia, PA 19114

Bell Helicopter Textron
P.O. Box 482
Fort Worth, TX 76101

Boeing Helicopters
P.O. Box 16858
Philadelphia, PA 19142

MBB Helicopter Corporation
900 Airport Road
West Chester, PA 19380

McDonnell Douglas Helicopter Company
500 E. McDowell Road
Mesa, AZ 85205

Sikorsky Aircraft
Flight Training Facility
West Palm Beach Airport
West Palm Beach, FL

As shown by the addresses on the list, interviews with these various manufacturers took place in a number of major areas of the U.S. Keeping that in mind, the operator interview process took place with those operators whose locations allowed for a reasonable travel itinerary during the manufacturer data collection process.

One of the purposes of the survey was to obtain the most accurate and candid information possible. Many operators did not wish to provide information that, if improperly used, could provide the basis for a regulatory investigation or violation. Therefore, prior to each interview, it was established that the information provided would be handled in a confidential manner and would not be published or identified with any operator by name. Thus, the field information entered into the data base does not contain the individual operator's identification. The field data does, however, cover all types of operators listed in the work program. The willingness and time availability of the key operator personnel played a large part in field selection of the operators.

4.3 SELECTED HELICOPTER MODELS

The data collected for the helicopter performance classification effort was based on a selected list of helicopters in use throughout the United States. In order to compare the survey data with the information contained in "Helicopter Physical and Performance Data," the same aircraft models were selected. These helicopters are:

- | | |
|---------------------|------------------------|
| o Enstrom F28F | o MBB BO 105 CBS |
| o MD 500E | o Sikorsky S-76A |
| o Bell 206B3 | o Aerospatiale 332C |
| o Aerospatiale 355F | o Boeing Vertol 234 LR |

While these helicopters were compared directly to the referenced report, they represent only 39 percent (3,656 aircraft [data from 1989 Rotor Roster, Air Track, Inc.]) of the U.S. fleet. Therefore, nine additional helicopters were profiled for purposes of developing a better understanding of procedures and operational requirements across a greater portion of the United States fleet (table 1). Of the 9,278 helicopters in the United States, the 17 models investigated in this report represent 67 percent (6,186). It is believed that the broad operational inferences gleaned from the database add to the depth of the study.

TABLE 1
ADDITIONAL HELICOPTERS SURVEYED

o Aerospatiale	o Hughes/McDonnell Douglas
- AS 350B	- H-369
- AS 350D	o Hughes/Schweizer
o Agusta	- H-269
- A-109	o MBB
o Bell	- BK117
- Bell 47	
- Bell 204	
- Bell 212	

4.4 PERFORMANCE CRITERIA

Specific criteria were used to provide a good basis of comparison between the data in the "Helicopter Physical and Performance Data" report and collected field data. The conditions for each surveyed aircraft included:

- A. aircraft weight - 70 and 85 percent of maximum gross weight (MGW) and 100 percent of maximum allowable takeoff weight;
- B. field elevations - Sea level, 3,000'+/-, 6,000'+/-, 10,000'+/-; and
- C. temperatures - ISA* and ISA + 20 degrees C.

* ISA - International Standard Atmosphere (15°C or 59° F at sea level).

Typical helicopter takeoff and landing procedures profiled included those taught by the manufacturers' flight schools and those utilized and observed in the field.

Many helicopters have an empty weight (plus pilot and minimal fuel) that is higher than 70 percent of the maximum gross weight limitation. For this reason a number of aircraft did not have the 70 percent of MGW classification performance charted.

5.0 DATA ANALYSIS

The data analysis portion of the study includes database development, the survey questions and answers, and preliminary analytical findings.

5.1 DATABASE DEVELOPMENT

A database of all relevant survey information was developed using Lotus' Symphony software. The database was used to catalogue survey responses and then group those responses into identifiable patterns.

5.2 SURVEY QUESTIONS AND ANSWERS

5.2.1 Operator Opinion Items

To create an effective survey, a common point of reference had to be developed in discussing operational techniques with helicopter operators and regulators. Different pilots are comfortable with different obstacle clearance margins. This is verified by the variety of helicopter pilot responses typically found in studies dealing with subjective pilot input. In this study, for example there were pilots who were comfortable clearing obstacles by as little as a foot or two while others suggested minimum clearance distances of 10 feet or more to clear the same obstruction.

In order to obtain meaningful operational data, a variety of obstacle scenarios were presented to the pilots being interviewed. The obstacle planes, shown in figures 1 and 2, were used as a basis for the scenarios. Pilots were asked to select an obstacle plane that provides a safety margin between the approach/departure path and the obstacle plane. By having pilots select obstacle planes in this manner, the planes can be related to approach/departure surfaces and a common frame of reference was achieved that is comprehensible to pilots, heliport regulators, and heliport designers.

Operators were also questioned as to the types of approaches or takeoffs that present greater risk, those approaches/departures that should not be used, minimum straight-in segment lengths on approach/departure, and information on acceleration distance effects upon performance. Questions on the operators' height-velocity (H-V) curve, operational policies, and general comments were also solicited and evaluated.

5.2.2 Federal Aviation Regulation (FAR) Part 135 Operations Inspectors

As part of the study effort, interviews across the country were conducted with FAA principal helicopter operations inspectors. These interviews did not use the survey instrument, but rather were conducted more informally with the primary purpose of gathering

background insight into the entire helicopter/heliport interaction issue. Information concerning operations specifications, special operations, and inspector input was solicited.

The FAA operations inspectors expressed confidence in the helicopter operators' continuing ability to make judgments and determinations related to safe helicopter operations at heliports.

5.3 SURVEY ADMINISTRATION

The survey instrument was administered to three groups:

- o helicopter manufacturers' flight instructors,
- o helicopter operators, and
- o heliport operators.

The same survey form was used for each group, with only minor modifications where needed.

Information derived from the helicopter manufacturers' flight school personnel provided takeoff and landing profiles for normal and maximum performance operations. Determination of the type of technique that the factory schools felt provided the most helicopter performance with respect to confined heliport operations was also solicited and is presented.

The helicopter operators provided the bulk of survey responses. After a common reference was developed, these respondents were able to provide valuable information concerning helicopter performance requirements and operating procedures.

The survey was administered in a similar manner to heliport and helicopter operators, with performance requirements based on the surveyed heliport's approach/departure slopes. The type of helicopters, percent of maximum gross weight (MGW) in relation to temperature and pressure altitude were observed and entered as a portion of the normal operator survey form. Special attention was given to plotting, to the degree possible, the actual approach and departure paths that the helicopters were using.

Once the initial database was established and sufficient representative field sheets were entered, a review of that information was made to see if any particular helicopter model was not being represented in relationship to its number in the fleet. No issues surfaced from preliminary review of the data that indicated a need for changes in the data collection method.

5.4 SURVEY ANSWERS

Question #1. Approaches and Departures: Operator estimate of any safety concerns, i.e., any type or classification of approaches and

departures that are not as safe as others. Is this affected by temperature or gross weight?

Results: An overwhelming majority of the pilots (59 out of 60) expressed concerns about the safety of vertical and/or steep approaches/departures, with seven of those pilots also having concerns about very shallow approaches/departures. The opinions were relatively unaffected by temperature and gross weight.

Question # 2: Any types of approach/departures that you feel should not be used?

Results: The majority of pilots who expressed an opinion stated that the greatest concern centered on the vertical and steep approaches and departures. Almost half of these pilots indicated the use of vertical or steep approach/departures are appropriate only when needed or required by the mission.

Question # 3: What are your preferred take-off and landing procedures, do they vary with temperature or gross weight?

Results: The operators responded with two separate and distinct groups of procedures for landings and takeoffs.

The first type dealt with procedures related to an unrestricted landing and takeoff location, whether it be a large heliport or an airport. The second type dealt with those procedures used during confined area landings and takeoffs. Each of these is discussed below.

A. Unrestricted Area

The responses for unrestricted areas fell into two broad categories:

- o Type #1 - Takeoff: This technique began with lift-off to a normal hover (i.e., 3 to 5 feet), followed by an acceleration to forward flight. The target airspeed and altitude most often mentioned was a 1 knot or 1 mile-per-hour (MPH) rate of increase in airspeed for each foot of altitude gained.
- o Type #2 - Takeoff: This takeoff method used the same 3 to 5 feet hover as the starting point; however, accelerating to take off safety speed (V_{toss}) was a predominant consideration throughout the maneuver. This was the procedure most often selected by the twin-engine operators.
- o Type #1 - Landing: The landing technique used an approach angle of approximately 8 to 10 degrees starting from a cruise configuration and speed and flying the approach, while maintaining an autorotative airspeed until landing was

assured either in that area or other suitable surrounding area.

- o Type #2 - Landing: Type #2 landings are steeper than Type #1, with the average being in the 12 to 14 degree range. One of the major goals during the approach was maintaining Vtoss as long as possible, up to reasonable limits of passenger and crew comfort.

The breakdown of responses to takeoff procedures in an unrestricted area correlated almost exclusively with the classification of single and twin engine helicopters. Of the 71 responses, 49 indicated using Type #1 take-offs and 20 reported using Type #2, with only 8 twin-engine operators indicating they were using Type #1 departures. All single engine operators with one exception reported using Type #1 procedures. The selection of landing procedure followed almost the same lines of twin engine versus single engine aircraft.

Changing helicopter gross weights did require minor changes in the techniques, mainly in power application and adjusting for acceleration rates. The basic technique, however, continued to be the same.

B. Confined Area

While small variations from operator to operator existed within the group of surveyed pilots, two takeoff and one landing technique emerged. In all types of operations, the pilots advocated making maximum use of available area.

- o Confined Area Takeoff Type #1: This technique was described as lift-off to a normal hover (i.e., 3 to 5 feet) and, after assuring there was sufficient reserve power to achieve the necessary climb angle, a departure at a constant climb angle needed to clear the obstruction was initiated. Airspeed beyond translational lift would be accepted, but obstacle clearance was the major objective. Once the obstacle (typically a maximum of 50 to 100 feet AGL in these discussions) was cleared, a normal departure climb was initiated. The application of takeoff power versus using only the power needed to perform the climb was the major difference between operators.
- o Confined Area Takeoff Type #2: This takeoff technique also started from a 3 to 5 foot hover; however, acceleration to takeoff safety speed was secondary only to clearing the obstacle. This was most often mentioned by twin engine helicopter operators. While some operators indicated a desire to climb vertically until above the obstacle and accelerate forward to climbing flight, these opinions were in

the minority. The use of the most shallow departure angle and the full area was also advocated.

- o Confined Area Landings: In almost all circumstances, the pilots interviewed opted for selecting and flying the angle closest to that of a normal approach. Again, a majority of twin engine operators indicated a desire to maintain an airspeed at or above V_{toss} for as long as a safe closure rate permitted.

The breakdown of responses to confined area operations also correlated noticeably with whether pilots were operating single or twin engine helicopters. Of the 65 responses, 45 indicated using Type #1 take-offs and 20 reported using Type #2. All single engine operators with one exception reported using Type #1 procedures.

Question # 4: Does this (confined area techniques) afford you more or less capability in the use of a confined heliport?

Results: The use of the techniques described in the confined area departures/approaches in all cases afforded the pilots additional capability in performing confined area operations. The use of the techniques described in the unrestricted area operations would severely limit the obstacle clearance path a helicopter could use.

During the interviews one item became rather clear. Many pilots valued the ability to make a takeoff without the use of full power. The reason consistently given was that the use of less than full power was a method of decreasing operating costs and increasing engine reliability through reduced wear and tear. In confined areas, the confined area takeoff type #1 departure is the procedure most operators described as the one which used the minimum amount of available power.

Twin-engine helicopter operators, concerned with continuing after an engine failure valued the safety margin that airspeed above V_{toss} provided them. The majority of the same twin operators also advocated the use of remaining engine limits above published limitations if needed to save the aircraft after the first engine failed.

Interviews with the aircraft manufacturers revealed the same consistency of two basic types of takeoffs/landings. Category A takeoffs and landings fall within the confined area takeoff/landing type #2 classification.

Most pilots did not feel extraordinary precautionary measures were justified in dealing with the possibility of a potential engine failure. However, most pilots believed that good operating practices should be adhered to including a willingness to risk potential aircraft damage in order to preserve passenger and crew safety.

Question # 5: At what point (in feet from takeoff point) in your takeoff profile would you feel comfortable in turning off a straight departure path? (Additional field descriptions provided as needed.)

Results: During the initial field interviews, concern with low altitude and low speed turns was voiced. For this reason, a description of a maneuvering turn was used during the interview process. This turn was described as less than a standard rate turn, using approximately a 10 degree angle of bank. This 10 degrees was established based on field observations, professional experience, and operator input. All conditions were given as zero wind, with the turns being made for obstacle clearance, noise abatement, better forced landing areas, air traffic separation, etc.

To the greatest degree possible, distance estimates used objects and areas familiar to the pilot being interviewed. In some situations where no other frame of reference was readily available, an actual measurement of the distance was taken.

In response to the question, almost 90 percent of the pilots indicated that an acceptable distance for turning off of a straight departure path was between 0 and 300 feet. Figure 5 illustrates the responses to this question.

Question # 6: What would you consider to be the comfortable minimum number of feet that a helicopter needs to be on a straight-in approach to a heliport? (Additional field descriptions provided as needed.)

Results: Similar to Question #5, this question had to be framed in terms that the pilots understood and related to on a day-to-day basis. The resulting answers were plotted, and again most (73 percent) of the responses indicated 0 to 300 feet as adequate for a straight-in approach distance to a heliport (see approach/departures distances - figure 5).

Editors Note: The FAA Technical Center conducted flight testing on this issue during November 1989 through August 1990. At this point, the data has not been analyzed in detail. However, for a 45 degree intercept to final approach the subject pilots recommend minimum straight segments substantially longer than 300 feet.

Question # 7: If the availability of "Acceleration Distance" prior to having to climb out over an obstacle(s) assists your performance, please indicate on the drawing what you feel is the minimum, ideal, and practical maximum of acceleration distance you would like to have at a heliport.

Results: During the interview process it became evident that the real question was what distance gave the operator an increase in performance. To this end, the explanation to the operator was structured to reflect a situation where the aircraft could carry a particular load out of a location and in addition, a mission

Approach/Departure Distances

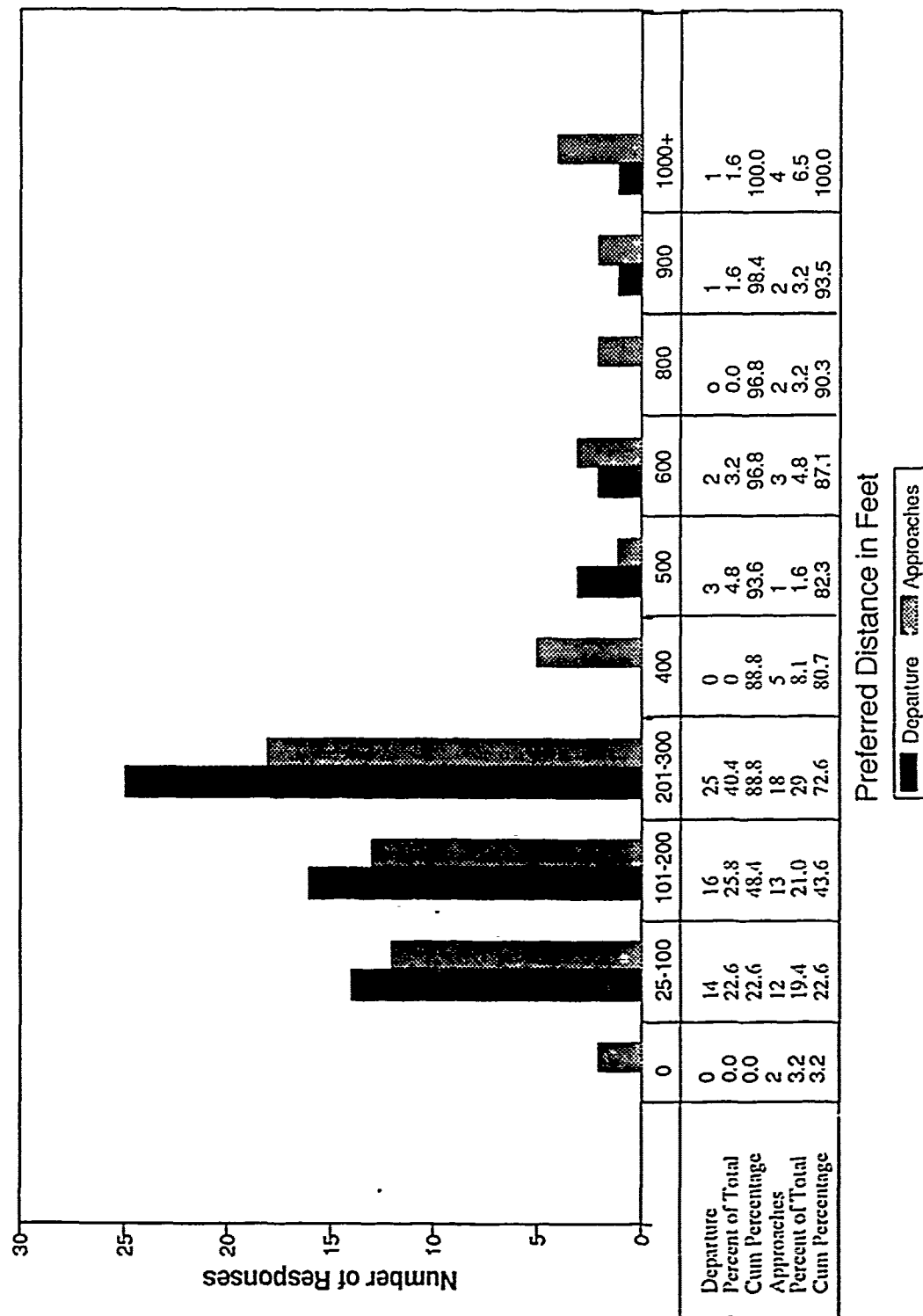


FIGURE 5 PREFERRED STRAIGHT IN APPROACH/DEPARTURE DISTANCES

requirement to add approximately 10 percent of the maximum gross weight of the aircraft became necessary. It was from this perspective that the responses were obtained. At the outset of the study many operators addressed this question in a similar manner. Given the availability of additional space at a heliport, the takeoff would commence at the furthest point from the departure end of the heliport and start as a normal departure.

For example, if a pilot was faced with an obstacle plane for which the controlling obstruction was a 30 foot pole 120 feet away from the helicopter, he/she would be faced with a 4:1 obstacle plane slope. If an additional 180 feet were made available for his/her departure, that would place the controlling obstruction 300 feet away, leaving the pilot faced with a 10:1 obstacle departure plane. Based on the perceptions of the interviewed pilots, a 4:1 obstacle plane would allow 69 percent of the single engine helicopters to depart under all conditions. Based on the same perceptions, the use of the 10:1 slope would allow 99 percent of the sampled helicopters to depart; a rather significant increase. (See appendix B, figure B-8, "Helicopter Performance, Single Engine, All Conditions").

In looking at the figures in appendix B, certain observations can easily be made. One significant finding was that the greatest amount of single responses was in the zero distance category. These operators placed very little value on acceleration distance. Without exception, the more shallow the obstacle plane, the less the acceleration distances would become. The determination of 100 feet, 200 feet, and 300 feet as the most mentioned minimum, ideal, and maximum approach/departure distances is a good example of the stepped and gradual concept followed by most helicopter operators.

No operator advocated or indicated a level acceleration much beyond the speed required to reach effective translational lift to be a desirable takeoff technique. Two manufacturer's chief training pilots and several others under the promise of confidentiality indicated they personally considered such a maneuver to be very undesirable due to safety considerations.

5.5 ADDITIONAL SURVEY RESPONSES

The subject of helicopter operations within the "avoid" areas of the height-velocity curve received numerous comments from pilots when the open-ended question of their treatment of H-V curves was posed.

The answers were broken down into three distinct categories:

1. They never operated within the H-V curve, as their operational mission profile did not require it.
2. Operations within the H-V curve are an accepted risk. Several missions, including photography, powerline patrol, lift work, rescue work, and confined areas work, required regular and

sometimes protracted periods of time within the H-V curve. These operators realized the risk exposure in the event of a power interruption. After taking all reasonable measures to preplan their exact actions and reduce as much as practical any controllable exposures, the risk was accepted as operationally required. Many of these same pilots, due to terrain or other considerations, accepted the fact that a safe and "no damage" landing might not be possible, regardless of the aircraft's autorotative capability. These same pilots, for the most part, felt that if aircraft damage was anticipated and indeed accepted, the accident would be survivable, providing proper techniques and preplanning were used.

3. Other operational factors transcend the H-V issue. For these operators a safe landing after losing all engine power or following a catastrophic mechanical failure was not anticipated irrespective of the takeoff or landing profile. Reasons cited were the frequency of rough terrain, obstacles, or demanding operating conditions such as high density altitudes.

It was noted in the interviews that height velocity charts in some aircraft, especially normal category helicopters, are based on a worst case situation and do not reflect a realistic representation of the helicopters' actual risk exposure to a less than "no damage" landing in the event of a power interruption.

The H-V curves should be provided for the range of helicopter operational conditions anticipated, and should use a graphical real-life representation in profile scale for information. The methodology of using pilot response delays for obtaining various H-V data points during certification tests should be reviewed to see if it is reflective of what the average helicopter pilot in today's industry is reasonably expected to perform.

6.0 ANALYTICAL FINDINGS

During the field collection process, a distinct variety of operational and performance related data emerged which had a very definitive effect upon the direction of the study. While some items were found only in a group of operators, such as those dealing with external load or EMS missions, certain universal operating techniques were found to apply throughout the entire industry. The major similarities are listed below.

1. Performance limitations influence and direct missions and the manner in which they are performed.
2. Modifications to reduce the fuel and/or passenger loads to accommodate landing or departing a particular heliport under demanding conditions are very common. Conversely, if an operator feels a particular load is mandatory, either a different site is selected or a partial load shuttle to an area allowing for the full mission load may be undertaken. Carrying less fuel than required for the desired mission and allowing for en route refueling is another widely used practice. Many sightseeing operations load just enough fuel for one or two runs, keeping extra fuel to a minimum. This allows for higher passenger loads or increased performance.
3. Pilot skill levels can significantly affect flight performance and the operating policies established by individual operators may affect payload carrying capability. For example, a Bell 206B3 may carry a full gross load on a standard day requiring 100 percent torque in order to depart a particular location. One operator may consider this perfectly acceptable, while others would not carry a load that allowed for less than a 10 to 15 percent power reserve. This characteristic was found with a number of operators and may be responsible for the variance in performance plottings as shown in appendix B.
4. Many operators, especially those along the Gulf Coast, have self-imposed restrictions on the maximum obstacle clearance plane at heliports from which they operate. This maximum obstacle clearance plane is typically no steeper than an 8:1 slope. This limitation is imposed on their operations regardless of the performance capabilities of their helicopters, the helicopter operating weights, or the ambient temperature. This limitation may be responsible for the similar performance plottings of single-engine and twin-engine helicopters. (It should be noted that the accident rate of the operators in the Gulf is appreciably lower than the rotorcraft industry as whole.)
5. There are many times when the operation of helicopters at maximum gross weight cannot be achieved. Temperature, altitude, obstacles in the vicinity, or company-imposed

operating policies are common limitations to the ability to operate at maximum gross weight.

6. All operators do not, nor do they reasonably expect to, operate at maximum gross weight under all conditions. The only possible exception is found in several of the high performance twin turbine helicopters.
7. Most operators felt their own hands-on experience was sufficient to judge, prior to any departure commitment, whether a helicopter could carry a particular load under a given set of conditions. The helicopter pilot typically performs a hover check. This hover check allows the pilot to determine power required considering all actual operating conditions. This also allows the pilot to ascertain the reserve power available and excess horsepower. During the hover, pilot experience is called upon to judge if the amount of power in excess of what is needed to hover is adequate to allow for a safe takeoff from the particular departure site.

Many of the items mentioned above, either singly or in specific combinations, account for the variety in the performance data collected. For example, a Bell 206B3 operated at maximum gross weight for one operator at sea level on a standard day would not be dispatched out of a heliport unless the obstacle clearance slope was 11:1 or shallower, while another Bell 206B3 at 6,000 feet under the same unadjusted temperature is reported to be operated with a 1:1 obstacle clearance plane, a highly significant difference. (It should be noted, however, that a steep departure such as this was only flown until the obstacle was cleared; then a normal departure climb was initiated.) Because the range of performance data for the same aircraft varies greatly, percentile calculations were used in this study in order to provide a basis for a flexible heliport airspace system.

7.0 SURVEY APPLICABILITY TO HELIPORT DESIGN CRITERIA

The data obtained from the survey represent a broad body of operational opinion regarding helicopter airspace requirements in the vicinity of heliports. As such, the survey results are a useful input to the establishment of heliport design criteria.

7.1 DESIGN CRITERIA DEVELOPMENT METHODOLOGY

As an aid to interpreting the survey results in a manner relating to heliport design criteria, the quantitative survey data were graphed with the design criteria data plotted as the independent variable (x-axis) and the cumulative percentage of responses plotted as the dependent variable (y-axis). The 90th percentile response level was chosen as a value significant for design criteria purposes. Certainly one can argue that other percentile values represent equally valid design points. However, based on the size of the survey and the experience of respondents, it is the opinion of the analysts that the 90th percentile represents an appropriate value for consideration as design criteria.

7.2 ANALYSIS OF THE 90TH PERCENTILE RESPONSES

The following quantitative responses were analyzed on a percentile basis:

1. pilots' desired obstacle clearance plane slope for single-engine helicopters (figure 6); standard and hot day temperatures; for 70, 85, and 100 percent maximum aircraft weight.
2. pilots' desired obstacle clearance plane slope for twin-engine helicopters (figure 7); standard and hot day temperatures; for 70, 85, and 100 percent maximum aircraft weight.
3. pilots' desired minimum required acceleration distance (figure 8); for a 2:1, 3:1, 5:1, and an 8:1 obstacle clearance plane slope.
4. pilots' preferred acceleration distance (figure 9); for a 2:1, 3:1, 5:1, and an 8:1 obstacle clearance plane slope.
5. pilots' desired maximum required acceleration distance (figure 10); for a 2:1, 3:1, 5:1, and an 8:1 obstacle clearance plane slope.
6. pilots' desired straight segment distances (figure 11) for departures and approaches.

7.2.1 Departure Slopes

The 90th percentile responses for the pilots' desired departure slope of both single- and twin-engine helicopters (items 1 and 2 in the prior list) are summarized in figure 12 in bar chart format.

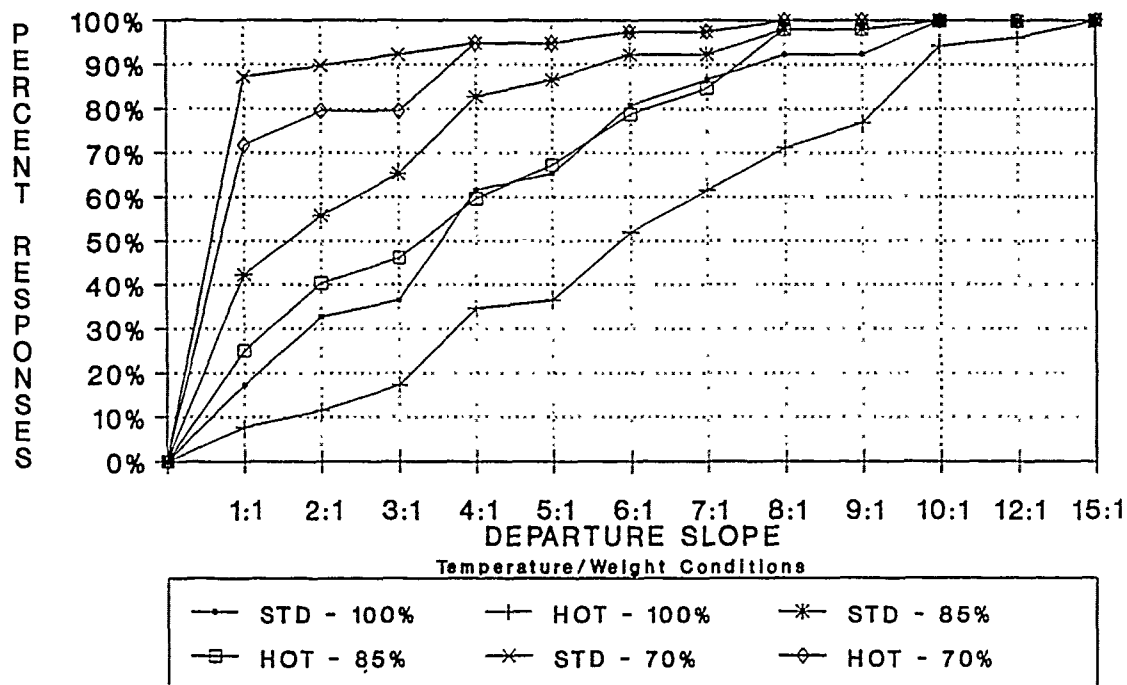


FIGURE 6 PILOTS' DESIRED DEPARTURE SLOPE - SINGLE ENGINE HELICOPTERS

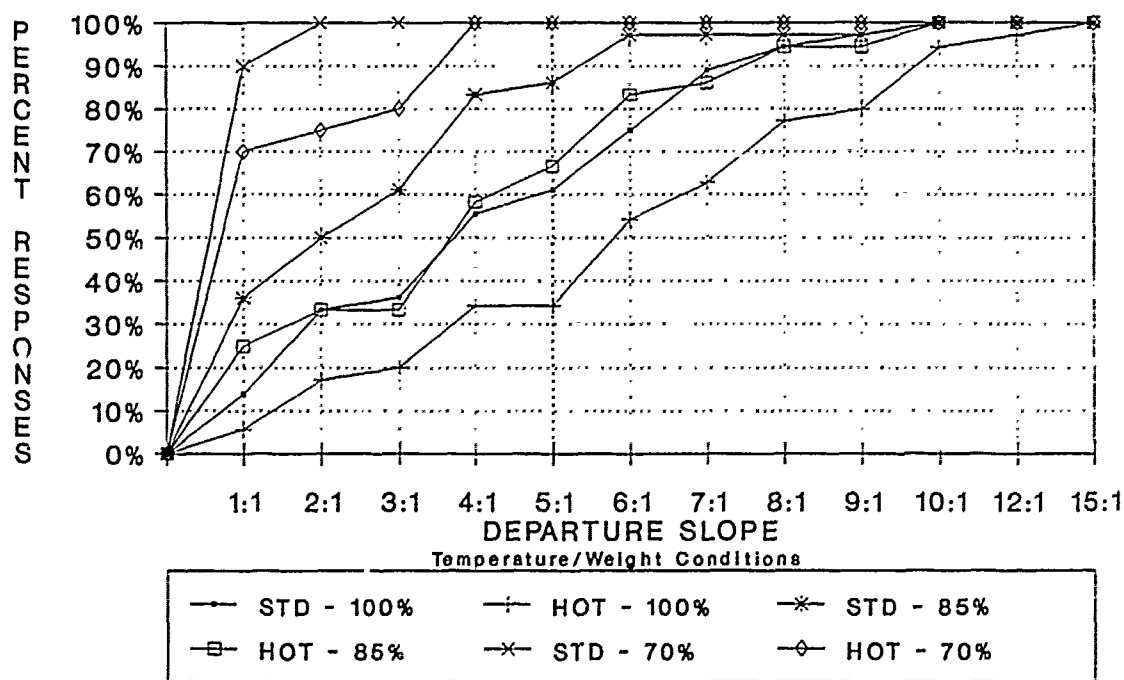


FIGURE 7 PILOTS' DESIRED DEPARTURE SLOPE - TWIN ENGINE HELICOPTERS

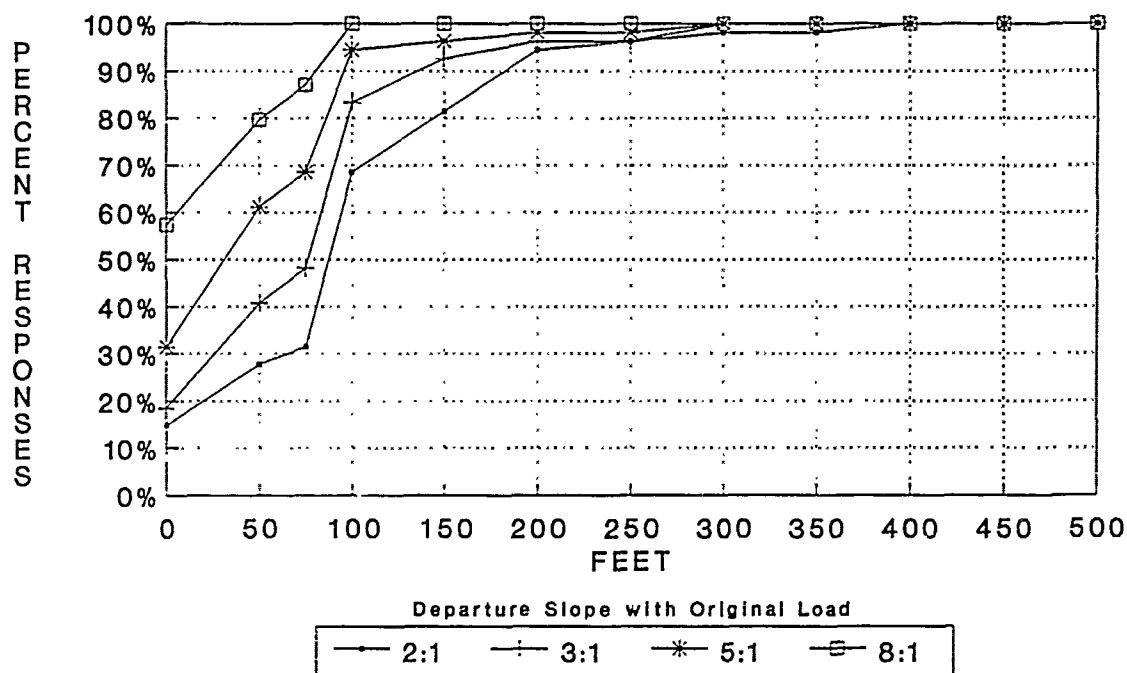


FIGURE 8 PILOTS' MINIMUM REQUIRED ACCELERATION DISTANCE FOR A 10 PERCENT INCREASED LOAD

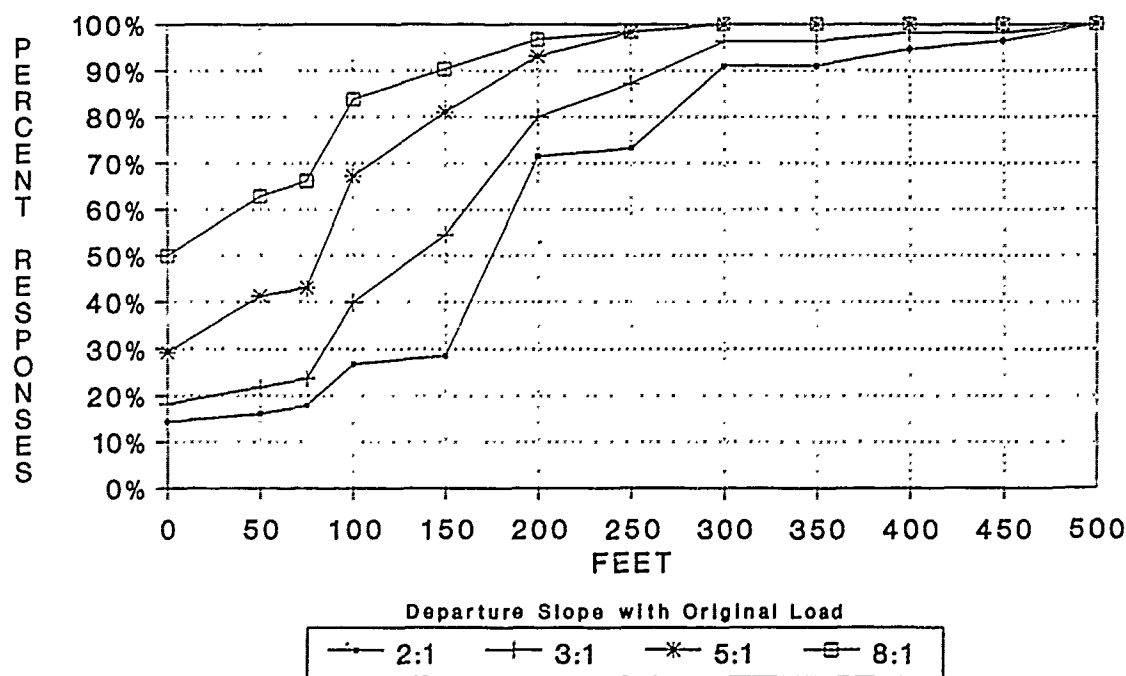


FIGURE 9 PILOTS' PREFERRED ACCELERATION DISTANCE FOR A 10 PERCENT INCREASED LOAD

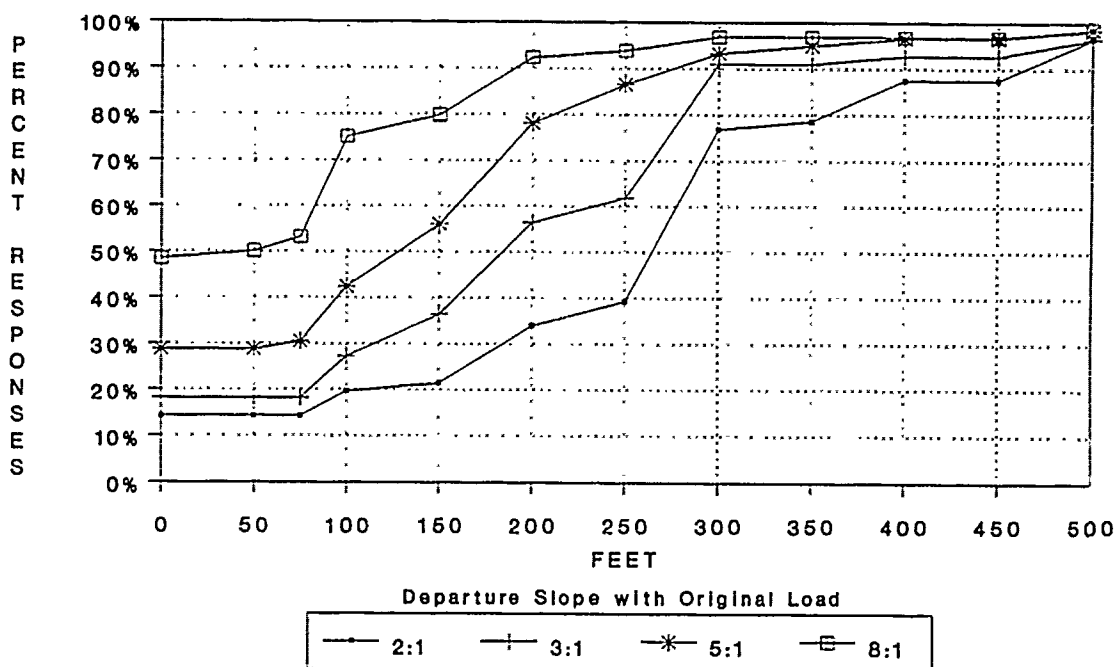
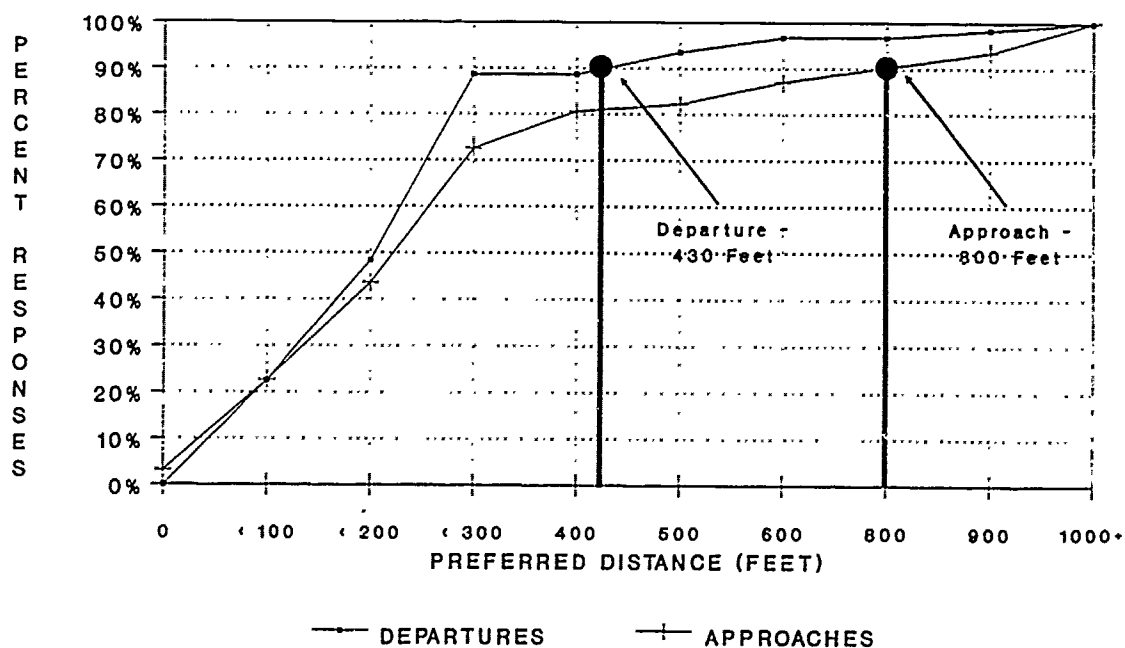
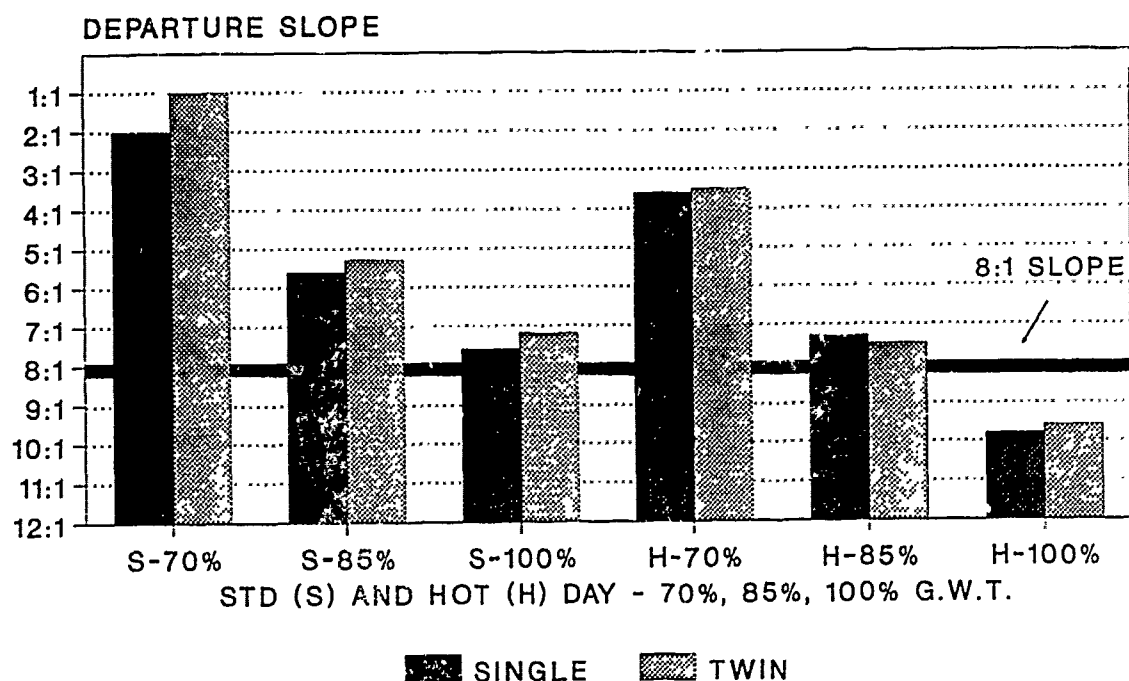


FIGURE 10 PILOTS' MAXIMUM REQUIRED ACCELERATION DISTANCE FOR A 10 PERCENT INCREASED LOAD



Departure - 430 Feet (90% of Pilot Responses)
 Approach - 800 Feet (90% of Pilot Responses)

FIGURE 11 PILOTS' PREFERRED APPROACH/DEPARTURE STRAIGHT SEGMENT DISTANCE



**FIGURE 12 PILOTS' DESIRED DEPARTURE SLOPE -
90 PERCENT RESPONSES**

For the six cases, very little difference is observed in the responses of pilots of single- and twin-engine helicopters. At first glance for the standard-day/70 percent-maximum-gross-weight case (S-70 percent), a difference is apparent in the 90th percentile responses (2:1 for the single-engine helicopter versus 1:1 for the twin-engine helicopter). However, looking more closely at the base data for the S-70 percent case in figure 6 shows that there is really very little difference in responses from the single- and twin-engine helicopter pilots. For the single-engine helicopter pilots, 87 percent of the respondents indicated they felt a 1:1 slope was acceptable as compared to 90 percent of the respondents of the twin-engine helicopter pilots.

The remaining five combinations of temperature and weight showed very consistent, and similar responses for the single- and twin-engine helicopter pilots. Generally, as the weight of the helicopter increases, the pilots want a shallower slope for the approach/departure surface. Similarly, as the temperature increases from standard day to hot day, so does the pilots' desire for a shallower slope for the obstacle clearance plane.

In five of the six conditions, the pilots' desired obstacle clearance plane slope is steeper than the 8:1 surface described in FAR Part 77 and the Heliport Design Advisory Circular. Only in the hot-day/100-percent-maximum-weight case does the pilots' desired approach/departure slope fall below the nominal 8:1 surface.

As noted in section 6, the pilots recognize operational limitations due to both high ambient temperatures and heavily loaded aircraft.

Paragraphs 2, 5, and 6 all discuss restrictions to operations under demanding conditions. In this regard the pilots' comments imply that on a hot day many pilots would limit their operations, either by reducing payload/fuel or by not operating at all, at heliports requiring a demanding approach/departure slope.

7.2.2 Acceleration Distance

The 90th percentile responses for the pilots' desired acceleration distance requirements are summarized in figure 13. To understand and interpret these responses the context of the acceleration distance question must be understood.

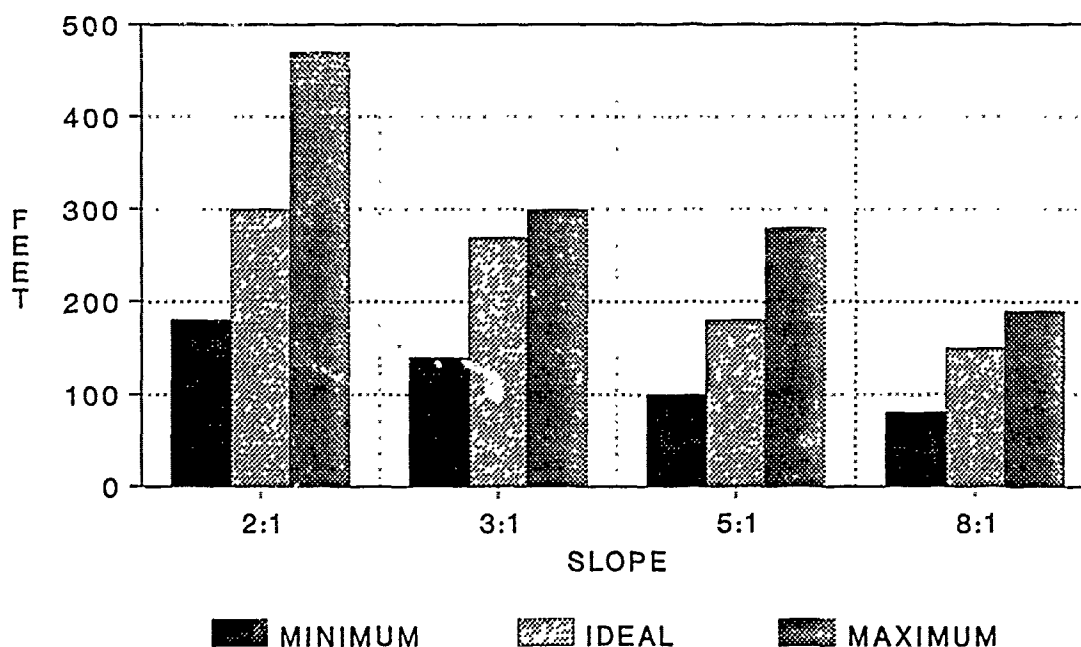


FIGURE 13 PILOTS' ACCELERATION DISTANCE REQUIREMENTS - 90 PERCENT RESPONSES

The pilots surveyed were presented with the situation where the helicopter could carry a particular load out of a location at a specific departure slope. The pilots were then told that the situation had changed and the mission requirement called for an increase in the load of approximately 10 percent of the maximum gross weight of the helicopter. Assuming additional distance was available, the pilots were then asked what distance, if any, would they add to the takeoff distance to achieve an increase in helicopter performance to accommodate the increased load. The pilots were requested to provide three answers as follows:

- a minimum distance, below which they would not takeoff;
- an ideal distance, described as a distance at which they would feel comfortable operating on a regular basis; and
- a maximum distance, above which the space would be wasted or the space would be better utilized for other purposes (e.g. parking cars, storage, etc.)

The results of the acceleration distance question, shown in figure 13, are consistent with operational expectations. The acceleration distance requirement increases directly with increased steepness of the departure slope. Using the ideal distance values as an example, in order to takeoff with the 10 percent additional load, the 90th percentile pilot would feel comfortable having 300 feet of additional distance to clear an object that he/she could initially clear with a 2:1 slope. On the other hand, he/she would feel comfortable having only 150 feet of additional acceleration distance to clear an object that he/she could initially clear with an 8:1 departure slope. In effect, in order to accommodate the additional load the pilot is reducing the departure slope by adding additional acceleration distance.

The survey results of greatest interest relative to the FAA's Heliport Design Advisory Circular are those of the 8:1 departure slope. These results relate directly to the approach/departure surface requirements found in the advisory circular. The 90th percentile survey results for the 8:1 departure slope are as follows:

8:1 Initial Slope Conditions

<u>Pilots'</u> <u>Distance Requirements</u>	<u>Additional Distance Desired to</u> <u>Takeoff with a 10 Percent Greater Load</u>
Minimum required to operate	80 feet
Ideal for most operations	150 feet
Maximum needed without wasting airspace	190 feet

7.2.3 Pilots' Desired Straight Segments

The pilots were asked to state their preference for the minimum straight segment before making a turn after takeoff from a heliport, and the minimum straight segment for the approach to a heliport prior to landing. The turn was described as less than a standard rate turn using approximately a 10 degree angle of bank. The cumulative percentage responses are shown in figure 11. The 90th percentile responses were as follows:

<u>Flight Phase</u>	<u>Straight Segment Distance</u>
Departure	430 feet
Approach	800 feet

7.3 SUMMARY OF HELIPORT DESIGN ISSUES

The analysis in this section reflects pilots' opinions regarding airspace requirements on or near heliports. The 90th percentile pilot responses were used as the criteria representing the majority opinion of the pilots interviewed. The summary findings from this analysis are as follows:

1. There is very little difference between the pilots' desired departure slopes for single- and twin-engine helicopters.
2. Under conditions of increased helicopter operating weights and/or increased operating temperatures the pilots' desired obstacle clearance plane slope becomes shallower.
3. Only for the 100 percent-maximum-weight/hot-day condition was the pilots' desired obstacle clearance plane slope shallower than the nominal 8:1 surface specified in the FAA's Heliport Design Advisory Circular. For the other five conditions studied (hot-day/70 and 85 percent-maximum-weight and standard-day/100, 85 and 70 percent-maximum-weight), the pilots' desired obstacle clearance plane slope was steeper than the 8:1 surface.
4. In order to accommodate increased loads of 10 percent of the maximum weight of the helicopter, the pilots' wanted additional takeoff distance. This distance provided room for the helicopter to accelerate to the speed of effective translational lift in order to achieve increased helicopter climb performance. Consider the situation where, without the additional load, the pilots could achieve an 8:1 slope. With the additional load the pilots desired additional distance ranging from 80 to 190 feet, with the ideal additional distance being 150 feet.
5. The pilots wanted minimum straight departure paths after takeoff from the heliport of 430 feet. On approaches, a minimum straight final approach path distance of 800 feet was desired. However, the turn to the final approach was described as less than a standard rate turn using approximately a 10 degree angle of bank.

8.0 SUMMARY OF SURVEY RESULTS

Relating the field data to the computer generated profiles presented in the "Helicopter Physical and Performance Data" report provides a number of comparisons.

A. Ninety eight percent of the pilots expressed concerns about the safety of vertical or steep approaches/departures and about 50 percent indicated the use of vertical or steep approaches/departures are only appropriate when required by the mission. Twelve percent of the pilots had concerns about very shallow approaches/departures. These opinions were relatively unaffected by temperature or gross weight.

B. Many pilots identified their flight manuals as the primary means to determine helicopter performance. However, when they were asked to provide specific information, these pilots clearly demonstrated they did not frequently reference the flight manual. Pilots typically searched for 10 to 15 minutes and then offered the out-of-ground effect hover ceiling chart as a reference to determine confined area takeoff capability. Hover in-ground effect charts were often referred to for departure capability from an unrestricted takeoff location.

C. The technique of accelerating to best angle of climb speed (V_x) or best rate of climb speed (V_y) prior to initiating a climb was not observed or described by any of the operators. Only in areas where no obstacles were in the flight path was a similar technique used. During those times, a climb was initiated once translational lift was achieved by the helicopter; however, it was a constant angle of climb rather than two distinctive segments.

D. Helicopter pilots expressed the desire, when operationally feasible, to avoid operating in the height-velocity curve. However, it is apparent that pilots often fly through portions of the H-V curve that the FAA and the manufacturers recommend be avoided. The premise found in the H-V+5 knot departure, although a correct solution for avoiding the H-V curve, did not appear to be in wide use in the field. Pilots typically had limited knowledge about the exact H-V curves for their aircraft and most had to refer to their flight manual for anything except broad approximations.

E. The height-velocity curves should be representative of the full range of operational weight, altitude, and temperature conditions encountered during normal operation of the helicopter. To facilitate pilot use, these curves should be depicted in the flight manual by a number of height vs velocity diagrams.

F. The computer-generated flight profiles presented in the "Helicopter Physical and Performance Data" report depict actual departure paths based on flight manual directed operational procedures and performance data. Selected departure profiles based on the operational field survey data are included in appendix C. These profiles depict the obstacle clearance planes that pilots felt would

provide comfortable clearance. The computer-generated flight profiles are not directly comparable to the operational survey data. The two data sets differ by the amount of obstacle clearance that the pilots felt was comfortable and safe.

G. A comparison of the S-76 profiles and the pilot interviews included in appendix C shows a difference in obstacle plane penetrations and factors very important to the development of any new system. Based on the pilot's perception of aircraft performance, the S-76A performs better than the certification data/performance modeling would indicate within a few hundred feet of the heliport.

H. Examination of the Bell 206B3 departure profiles reveals similarities with the S-76A profiles. Based on the interviewed pilots perception of aircraft performance, the Bell 206B3 performs better than the certification data/performance modeling would indicate within a few hundred feet of the helipad.

APPENDIX A
PASSENGER TRANSPORT HELICOPTER OPERATIONS OVERVIEW 1952 - 1990

A number of helicopter transport services were conducted in the 1950's, including those by New York Airways (NYA). This service started in 1952 using S-55's but limited its initial scheduled service to mail only. By 1953 NYA operations had expanded to include passenger service. In 1956 it added S-58's and later in 1957 dropped the Sikorsky helicopters for single engine piston Vertol V-44B's (15 passengers). Subsequently in the early 1960's, the V-44B's were replaced by Vertol V-107 (25 passengers) twin engine helicopters. In the final years of operation the V-107's were replaced with S-61L's.

Los Angeles Airways (LAA) started in 1954, also using Sikorsky S-55's (single-engine piston - 7 passengers). By 1956 LAA had 72 daily flights and their operation continued to increase. In 1962 LAA received its first twin turbine helicopter, the S-61L (28 passenger) and continued to operate an extensive network. Chicago Helicopter Airways (CHA) had a similar background to LAA, starting in 1956 with Sikorsky S-55's, but they decided to use S-58's (single engine piston 12 - passengers) in 1958 to enhance their service.

Early in 1961 San Francisco Oakland Airlines (SFO) commenced passenger services using 2 S-62's (single engine turbine - 10 passengers). SFO continued to expand its service with S-62's, until 1965 when it added 3 twin turbine S61N's (26 passengers).

All four of these operations were subsidized. The subsidies were withdrawn in 1965. Also at this time the employees formed a union. These factors, combined with a sluggish economy, and in some cases, major accidents, resulted in a downward trend for all four operators. LAA eventually closed in 1970. SFO, who initially stopped in 1966 but restarted in 1969, also closed in 1970. CHA ceased operations in 1975. NYA went out of business in 1979.

In most cases these major operations initiated service with single, piston-engine helicopters and thus were operated under Category B standards. The use of twin engine helicopters increased in the early 1960's. The introduction of FAR Part 127 essentially dictated that "operations of scheduled air carriers with helicopters" should conduct operations under Category A takeoff and landing procedures.

There was some confusion with the FAA and CAB definitions of "Large Helicopters". The result was that Part 127 covered all scheduled operations with "Large Helicopters". As far as can be determined, operations by LAA, SFO, and NYA with "twin-engine helicopters" were conducted under this framework. Some operations for LAA were allowed under Category B, although most were carried out using Category A performance standards. LAA and SFO used "free field Category A" (normal Category A), while NYA used "vertical Category A" (or zero field length Category A) from the rooftop heliport on the Pan Am building in New York City. The impact of this upon NYA had a dramatic effect on performance, and the V107 (capable of carrying 25 passengers) was often limited to 8 passengers on hot days. The impact of "zero field length" Category A, which is similar in most respects

for most twin engine helicopters, can be illustrated for the S-61N. For the NYA S-61 with a maximum take-off weight of 19,000 lbs (since that time, increases in maximum gross weight have occurred), the free field Category A at 35 degrees C/95 percent power is 16,900 lbs, while for "zero field length it falls to 14,900 lbs. This compares to the empty weight of 12,510 lbs."

Following the demise of the major operators during the 1970's, a number of smaller schedule and air taxi (charter) operations were started. Most of these used single engine or small twin engine helicopters. The exception was New York Helicopters which began operations in the early 1980's and did not remain in business for very long. Also, during this period there was little activity in the area of regulatory changes. Most scheduled helicopters operated under FAR part 135 used by the small, fixed-wing commuter. Part 135 did not specify takeoff/landing performance requirements and thus Category B operations became the norm.

Airspur, in 1983, initially considered using Category A from the (new) Los Angeles Airport (LAX) roof top heliport with twin engine Westland 30's. To survive economically however, Airspur had to operate at weights above those allowable under Category A. Even Category A/IFR at the time appeared to be interpreted in a very liberal manner, resulting in most operations being conducted under Category B.

Pan Am/Omniflight began operating the twin turbine Westland 30 (15 passengers) from New York's 60th Street Heliport in 1987. They used Hover Out of Ground Effect (HOGE) performance for the take-off reference weight. This corresponds to a performance approximately midway between "free field Category A" and Category B, and thus technically Category B operations were flown.

Most other operations in the U.S. use either single engine helicopters and are thus Category B by definition, or fly Category B with twin engine helicopters. The only major exception are some corporate operators who use S-76's and use Category A performance wherever possible.

In the last few years Resorts International commenced a service from New York to Atlantic City. Resorts was subsequently taken over by Trump Airlines, and very recently an additional service from La Guardia to the Wall Street Heliport was introduced. Those services, which are not required to operate Category A due to SFAR 38-2, would appear to operate at a performance level that can be best described as "quasi Category A," where under cruise conditions, flight with one engine inoperative can normally be maintained.

Trump has recently purchased and is placing into service two Boeing 234's. Because of their large fuel and endurance capacity, even with full passenger and baggage loads, the BV 234 presumably will be operated within Category A weight limitations without posing any operational or economic hardship on the Trump operation.

APPENDIX B SURVEY-BASED PERFORMANCE CHARTS

This appendix contains the results of the pilot survey responses in tabular and bar chart formats (figures B-1 through B-13). Several of the charts are analyzed in an attempt to identify breakpoints for a logical classification system. Responses in the not applicable (N/A) column describe answers by pilots stating that they never operate at weights as low as 70 percent of maximum gross weight.

The first chart that was examined was helicopter performance for All Helicopters, All Conditions (figure B-1). The first observation from a helicopter/heliport interface is the high concentration of helicopter pilots (92.9 percent) indicate that they operate under all conditions with a 8:1 obstacle clearance plane. Taking this one step further, there are still 81.2 percent of the pilots which claim to be able to operate with an obstacle clearance plane of 6:1.

In order to develop a better understanding of the true restrictions being realized by operators in the field, an analysis of helicopter performance was made. This analysis included all helicopters under the most restrictive conditions, i.e., maximum gross weight (MGW), standard day at sea level (referred to as slope A) and MGW, standard day +20 Degrees C at sea level (referred to as slope B). While over 92 percent of helicopters are said to operate with an obstacle clearance plane of 8:1 under MGW, standard day at sea level, this dropped down to 73.8 percent when temperatures increased 20 degrees C.

NOTE: The higher elevation operations data from the survey were examined to determine what influence they had on the overall results. Surprisingly, the high altitude operations, perhaps due to different operational policies and experience levels, actually realized a higher level of performance than the industry as a whole.

Another observation from the All Helicopters, A and B Slope chart (figure B-2) is the broad spread of responses. While there is a shift reflecting decreased higher temperature performance, a clear point still does not emerge which would encompass a realistic categorization for all helicopters. Because there is a broad range of helicopters with a wide breath of performance capabilities covered in this chart, additional breakouts were performed for the two most popular single and twin engine helicopters, the Bell 206B3 (figures B-3 and B-4) and the Sikorsky S-76A (figures B-5 and B-6).

An examination of the Bell 206B3 All Conditions Chart (figure B-3) reveals a response spread and distribution very consistent with the entire fleet as a whole. Over 90 percent of the responses fell in the 8:1 slope and above, with almost 85 percent still operating at 6:1 or above. To evaluate further the potential of a helicopter performance classification system, the worst case conditions at MGW, standard day at sea level slopes for the Bell 206 B3 were examined.

The consistent shift found between the MGW, standard day at sea level slopes on the other charts is also evident here. The very wide spread

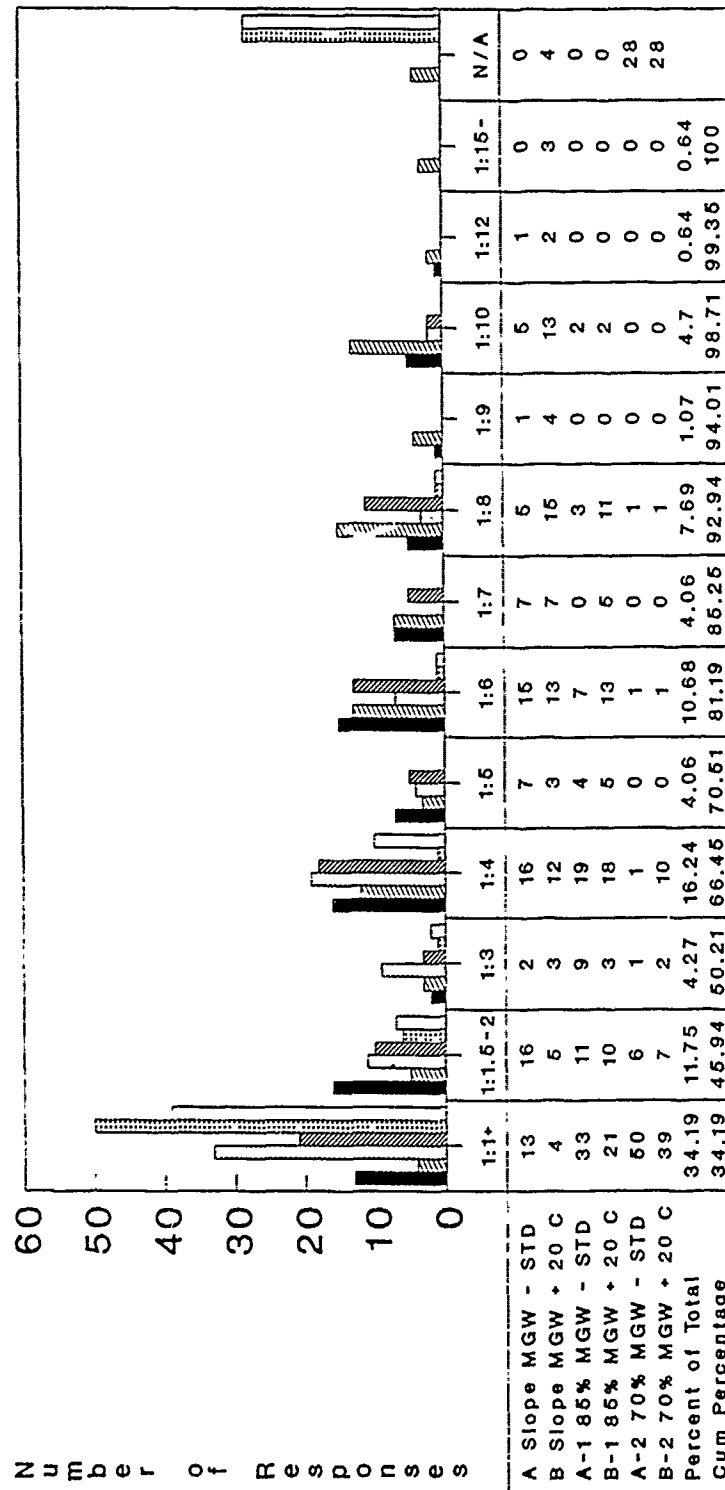
of responses does not indicate any one point which would serve as a classification break point for the Bell 206 B3.

The same detailed examination took place for the S-76A. While the distribution of responses shifted more between the 5:1 to 8:1 range (figure B-5), that probably is reflective more of operational policies than actual aircraft performance. Even after the breakdown in the A and B slopes classification (figure B-6), a single point or operational feasible range does not emerge.

As a matter of comparison, both single and twin engine helicopters were profiled under all conditions (figures B-7 and B-8). Again, even when examined separately, the same 90 percent +/- for the 8:1 and 80 percent +/- for the 6:1 slopes were evident. The same broad spread of responses was found in the individual charts throughout the range of conditions.

The results of a percentage analysis of all aircraft under all conditions were rather conclusive (figure B-9). Irrespective of exact aircraft type the percentage of responses in each obstacle clearance plane column was remarkably similar to other classifications and the industry as a whole. The greatest difference in response was in the obstacle plane of 1:1 or over. Even then the differential between aircraft was slightly over 2 percent, an operationally insignificant margin.

Helicopter Performance All Helicopters, All Conditions

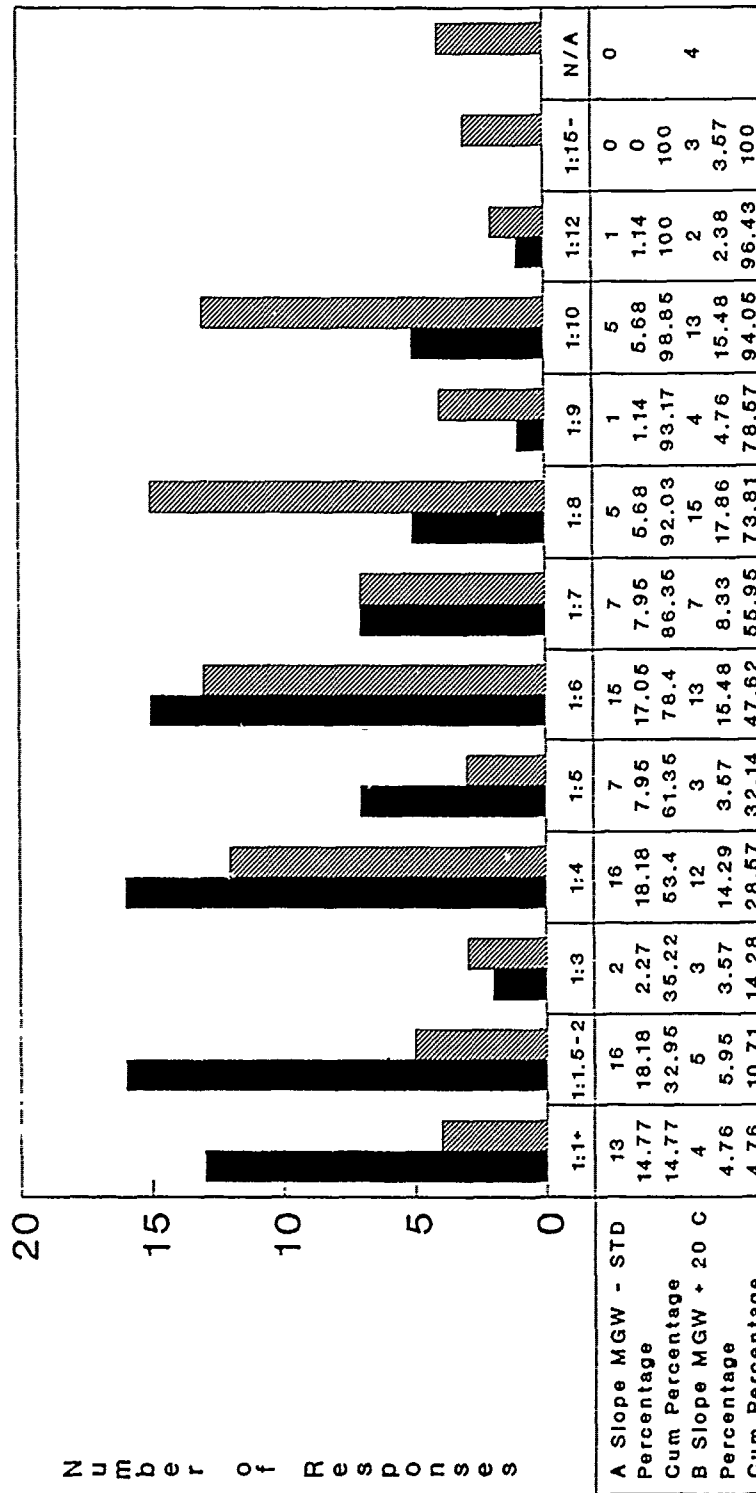


Obstacle Clearance Plane

A Slope MGW - STD
 B Slope MGW + 20 C
 A-1 85% MGW - STD
 B-1 85% MGW + 20 C
 A-2 70% MGW - STD
 B-2 70% MGW + 20 C

FIGURE B-1 HELICOPTER PERFORMANCE ALL HELICOPTERS, ALL CONDITIONS

Helicopter Performance All Helicopters, A and B Slope

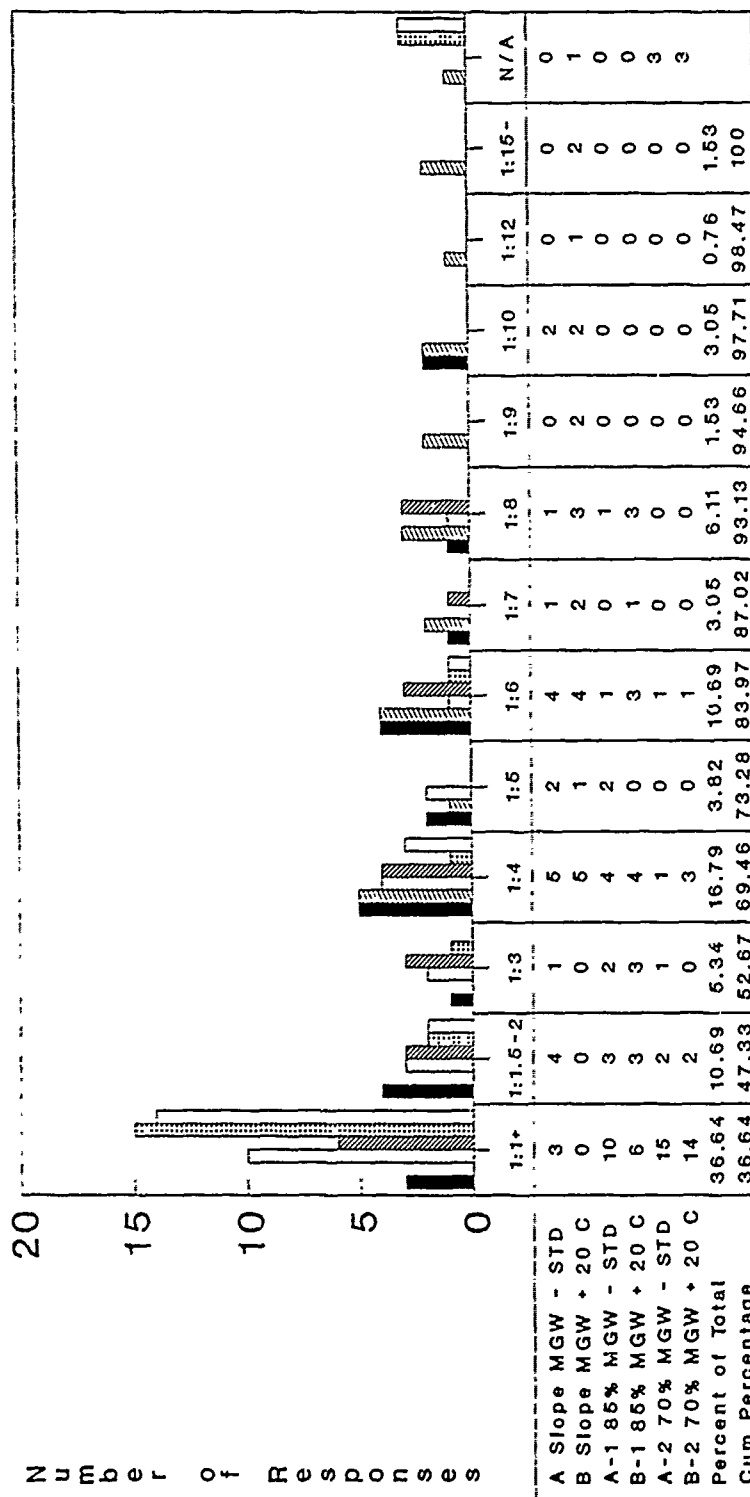


Obstacle Clearance Plane

■ A Slope MGW - STD ▨ B Slope MGW + 20 C

FIGURE B-2 HELICOPTER PERFORMANCE ALL HELICOPTERS, A AND B SLOPE

Helicopter Performance B-206B3, All Conditions

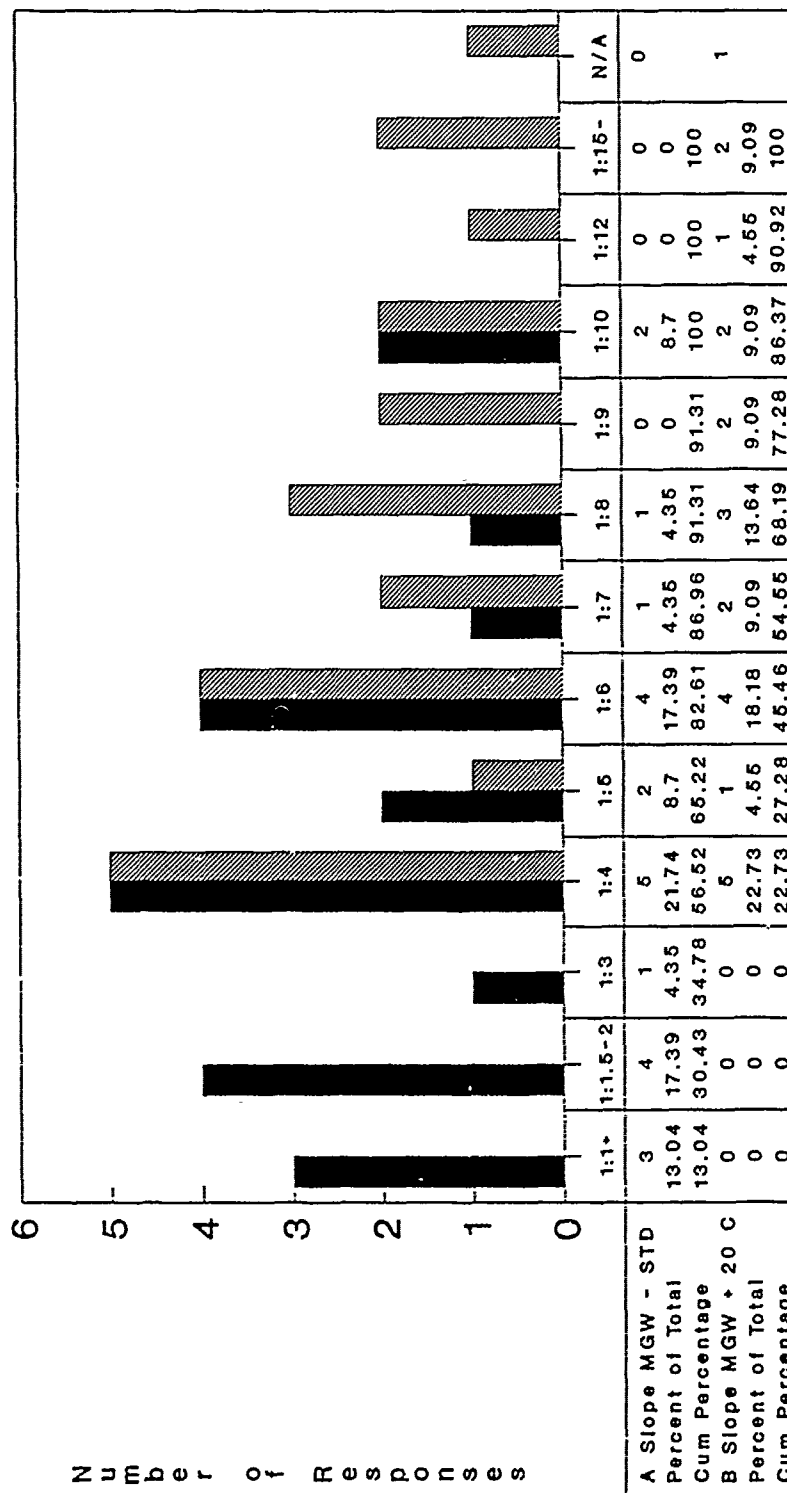


Obstacle Clearance Plane

A Slope MGW - STD
 B Slope MGW + 20 C
 A-1 85% MGW - STD
 B-2 70% MGW + 20 C

FIGURE B-3 HELICOPTER PERFORMANCE B-206B3, ALL CONDITIONS

Helicopter Performance B-206B3, A and B Slopes

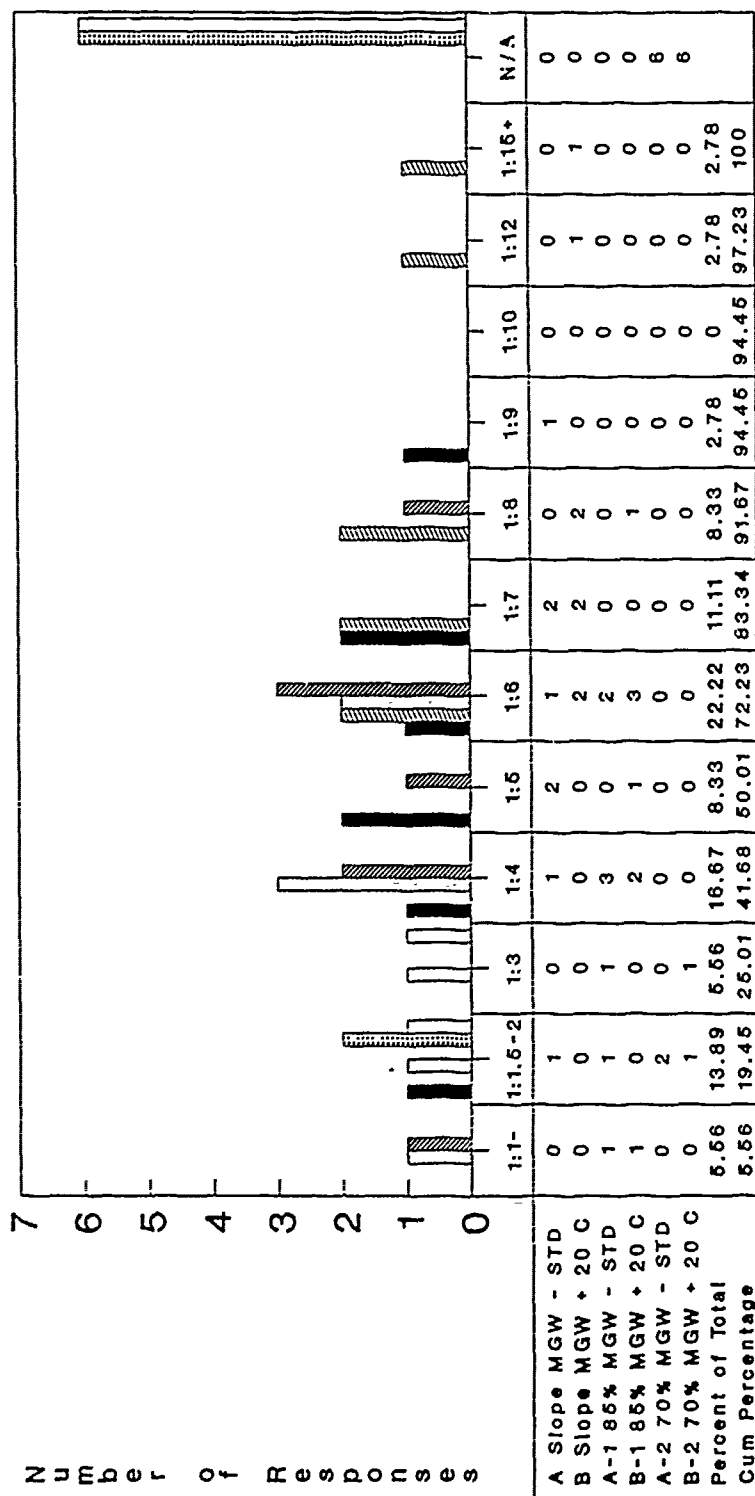


Obstacle Clearance Plane

■ A Slope MGW - STD ▨ B Slope MGW + 20 C

FIGURE B-4 HELICOPTER PERFORMANCE B-206B3, A AND B SLOPES

Helicopter Performance S-76A, All Conditions



Obstacle Clearance Plane

A Slope MGW - STD
 B Slope MGW + 20 C
 A-1 85% MGW - STD
 B-1 85% MGW + 20 C
 A-2 70% MGW - STD
 B-2 70% MGW + 20 C

FIGURE B-5 HELICOPTER PERFORMANCE S-76A, ALL CONDITIONS

Helicopter Performance S-76A, A and B Slopes

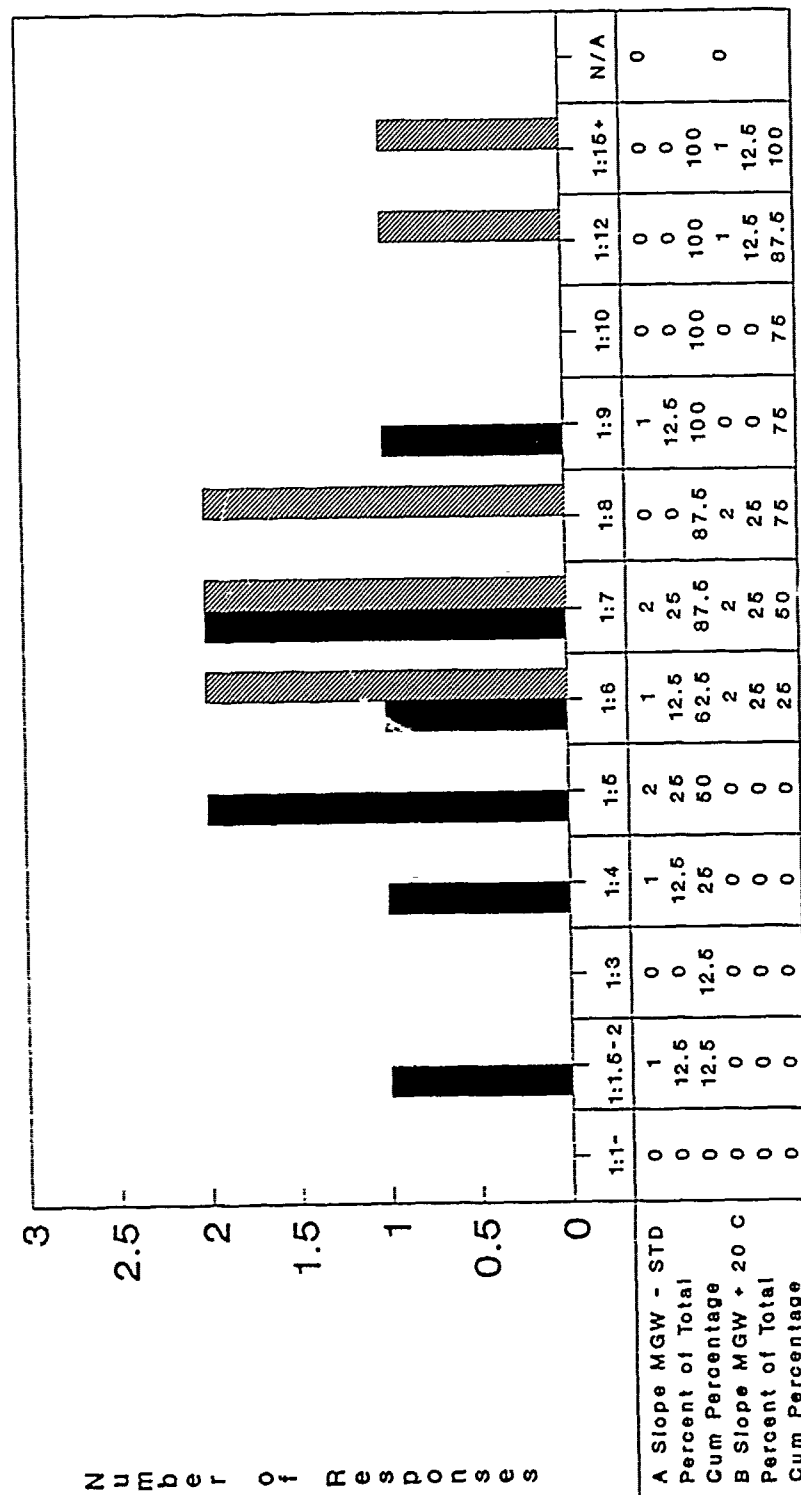
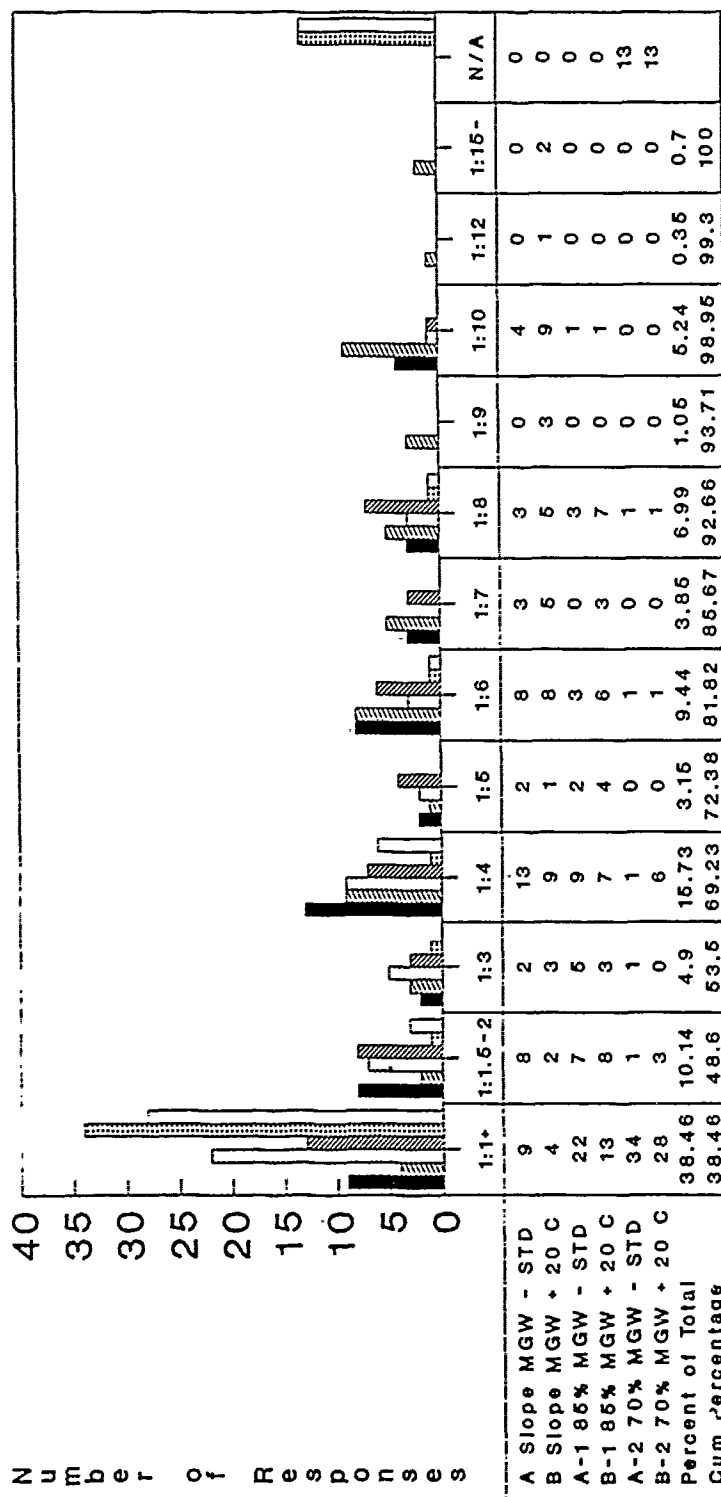


FIGURE B-6 HELICOPTER PERFORMANCE S-76A AND B SLOPES

Number of Responses	Ratio												N/A
	1:1+	1:1.5-2	1:3	1:4	1:5	1:6	1:7	1:8	1:9	1:10	1:12	1:15-	
A Slope MGW - STD	5	7	1	7	2	5	5	2	1	1	0	0	0
B Slope MGW + 20 C	2	4	1	5	0	7	3	5	1	5	1	1	0
A-1 85% MGW - STD	13	5	4	8	1	4	0	0	0	1	0	0	0
B-1 85% MGW + 20 C	9	3	0	9	3	6	1	3	0	2	0	0	0
A-2 70% MGW - STD	18	2	0	0	0	0	0	0	0	0	0	0	16
B-2 70% MGW + 20 C	14	1	1	4	0	0	0	0	0	0	0	0	16
Percent of Total	38.69	9.56	3.52	17.09	3.02	10.05	3.52	7.54	0.5	5.53	0.5	0.5	
Gum Percentage	38.69	48.24	51.76	68.85	71.87	81.92	85.44	92.98	93.48	99.01	99.5	100	

B-9

Helicopter Performance Single Engine, All Conditions



Obstacle Clearance Plane

■ A Slope MGW - STD
 ▨ B Slope MGW + 20 C
 ▩ A-1 85% MGW - STD
 ▧ B-1 85% MGW + 20 C
 ▦ A-2 70% MGW - STD
 ▤ B-2 70% MGW + 20 C

FIGURE B-8 HELICOPTER PERFORMANCE SINGLE ENGINE, ALL CONDITIONS

Helicopter Performance All Conditions, Percentage Analysis

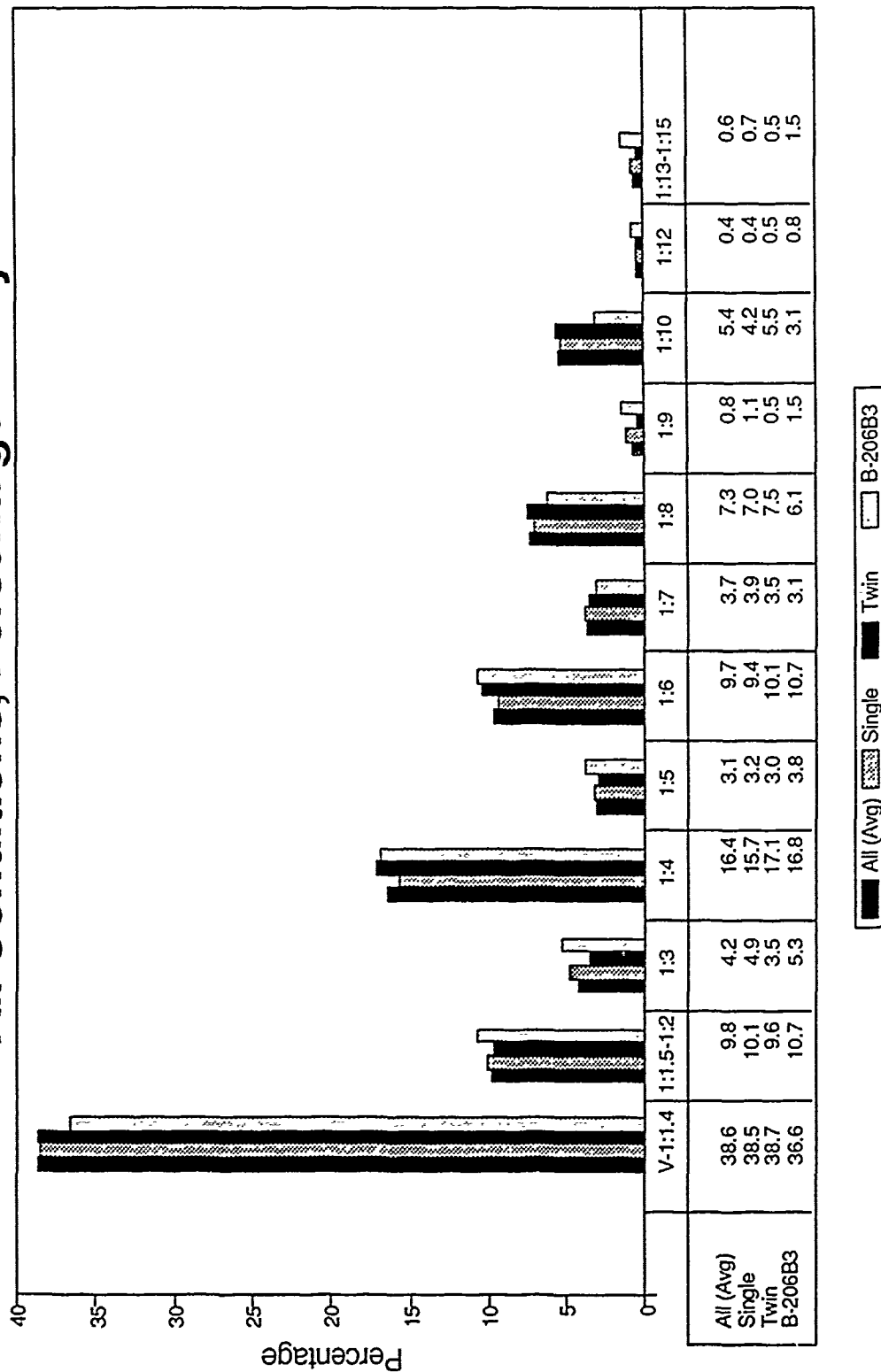
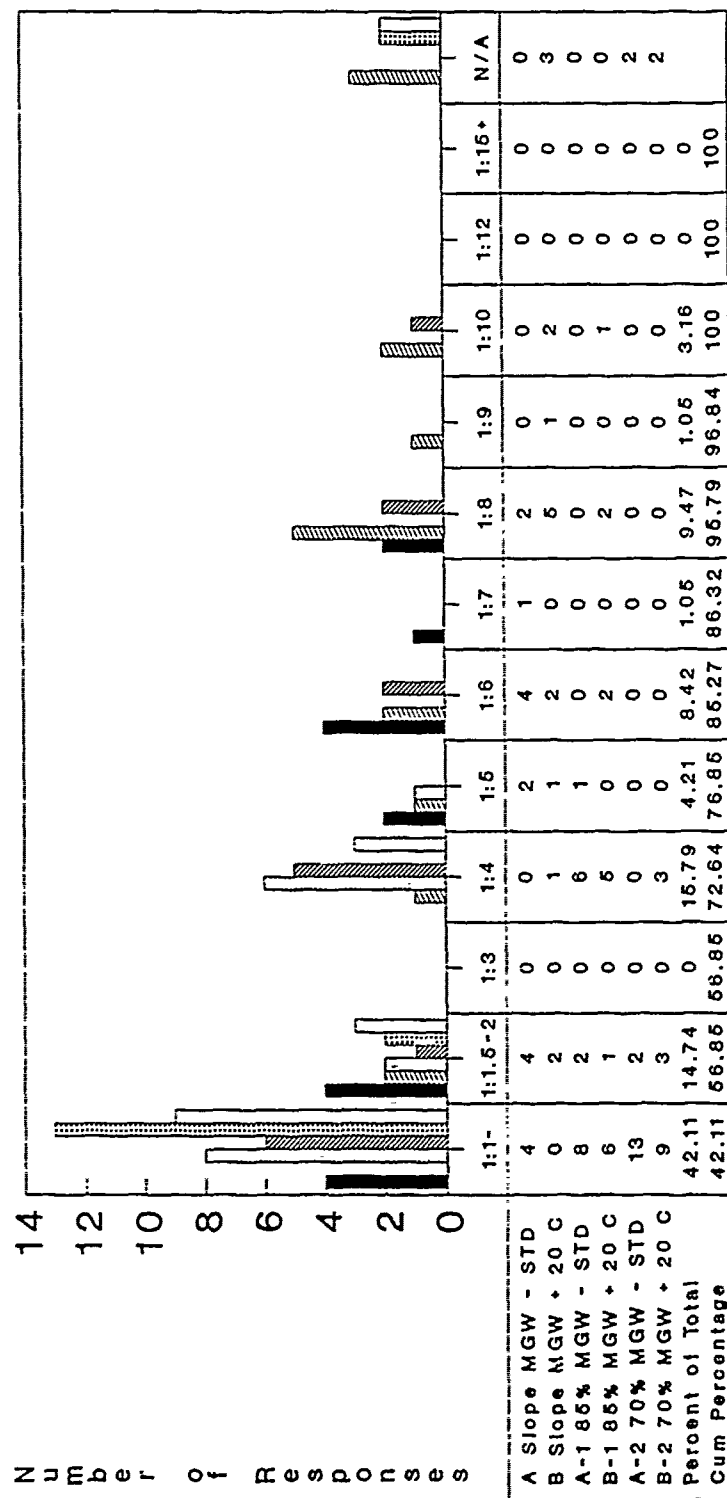


FIGURE B-9 HELICOPTER PERFORMANCE ALL CONDITIONS, PERCENTAGE ANALYSIS

Helicopter Performance High Altitude



Obstacle Clearance Plane

■ A Slope MGW - STD ▨ B Slope MGW + 20 C □ A-1 85% MGW - STD
 ▤ B-1 85% MGW + 20 C ▩ A-2 70% MGW - STD □ B-2 70% MGW + 20 C

FIGURE B-10 HELICOPTER PERFORMANCE HIGH ALTITUDE

Acceleration Distance All Helicopters, Minimum Distance

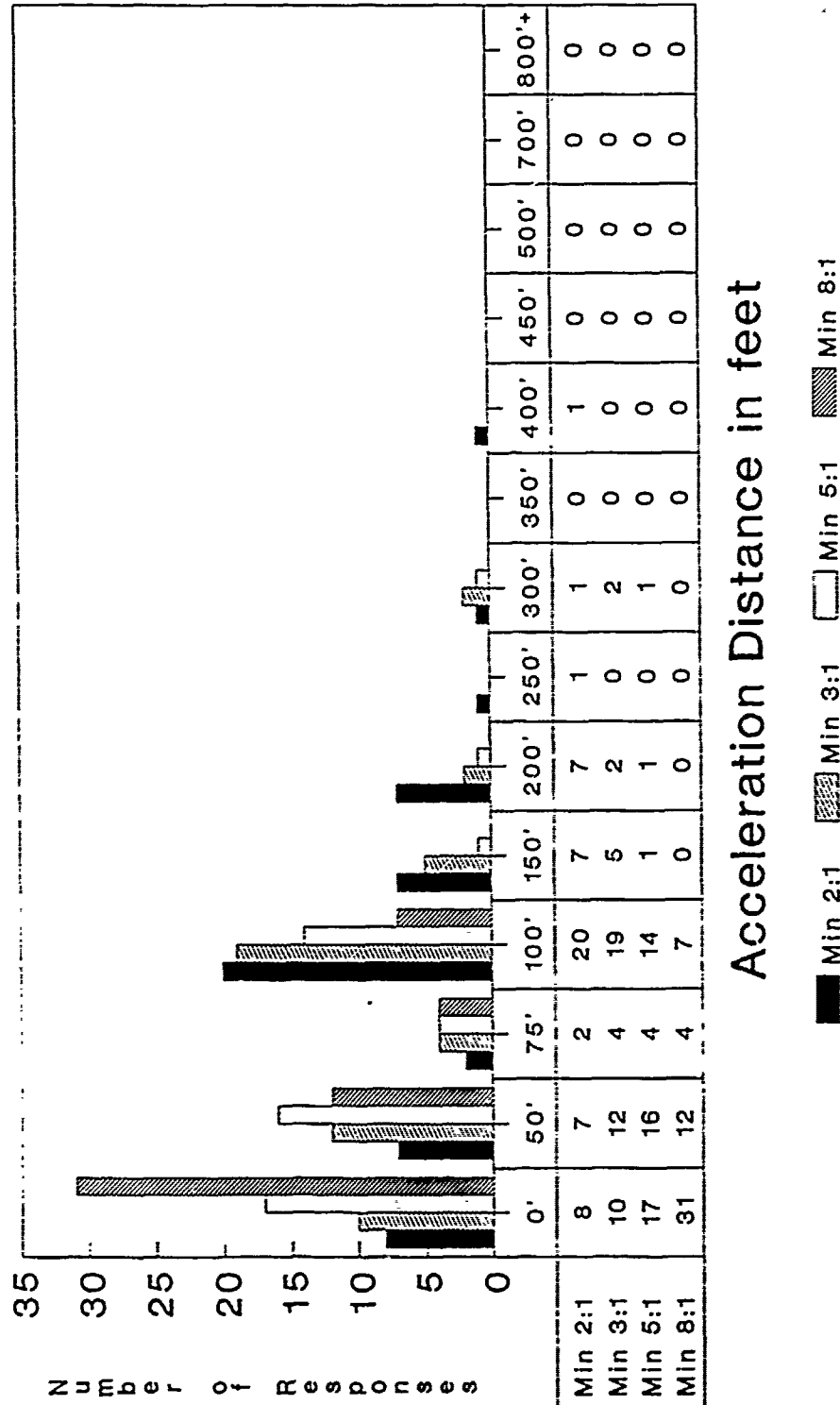


FIGURE B-11 ACCELERATION DISTANCE ALL HELICOPTERS, MINIMUM DISTANCES

Acceleration Distance All Helicopters, Ideal Distance

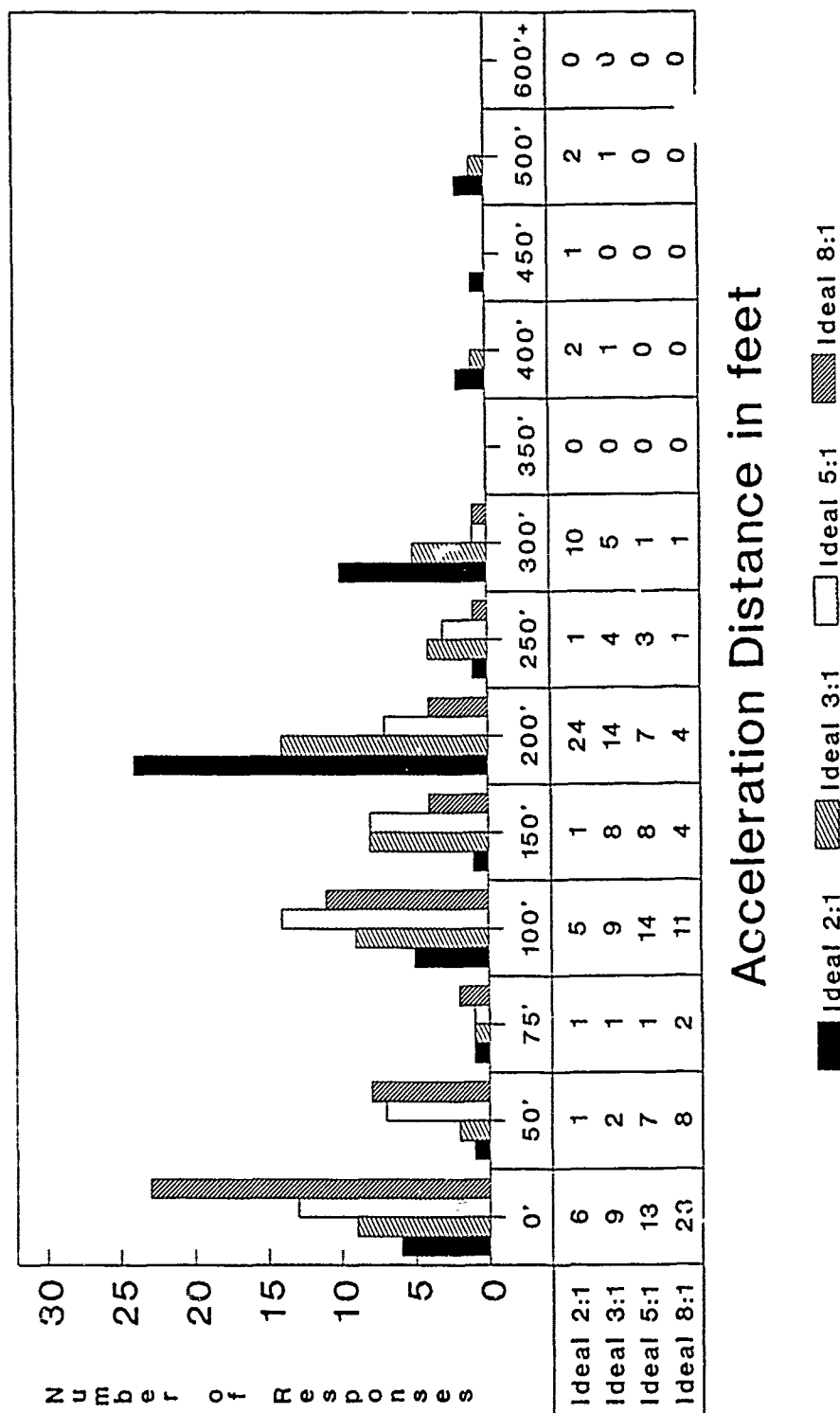


FIGURE B-12 ACCELERATION DISTANCE ALL HELICOPTERS, IDEAL DISTANCE

Acceleration Distance All Helicopters, Maximum Distance

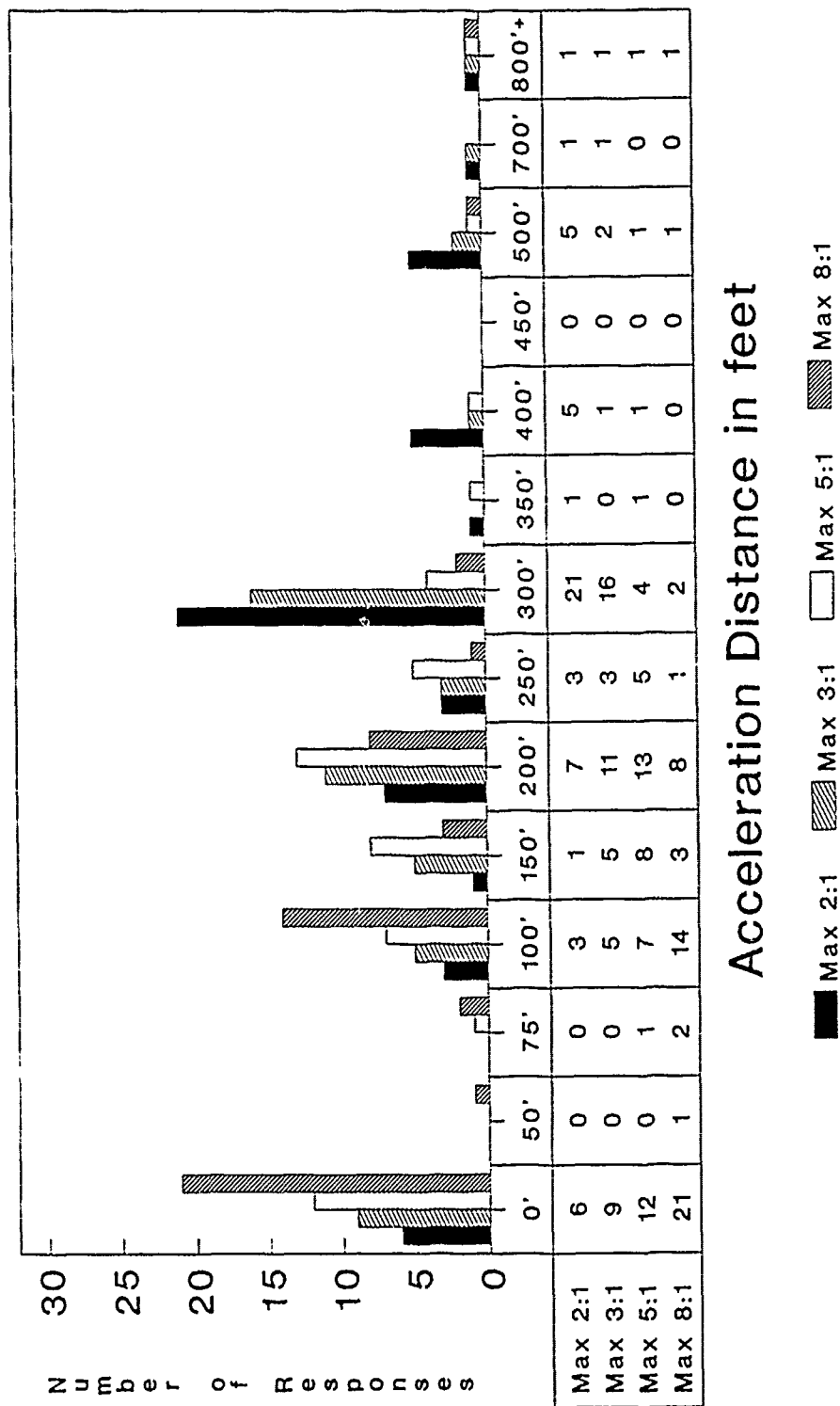


FIGURE B-13 ACCELERATION DISTANCE ALL HELICOPTERS, MAXIMUM DISTANCE

APPENDIX C
DEPARTURE PROFILE COMPARISONS

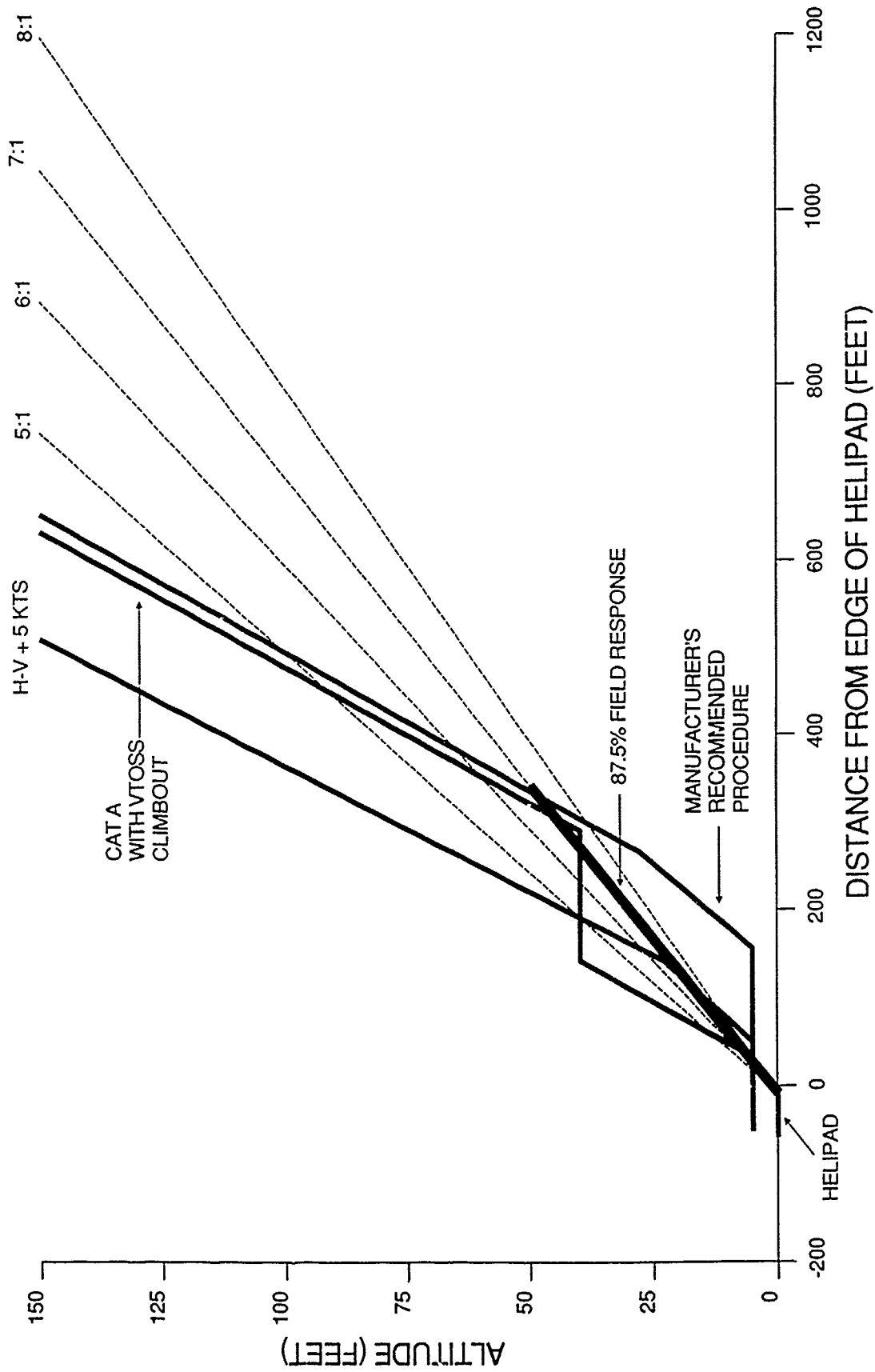


FIGURE C-1 S 76A DEPARTURE PROFILES MAX. G.W., SEA LEVEL, STANDARD DAY

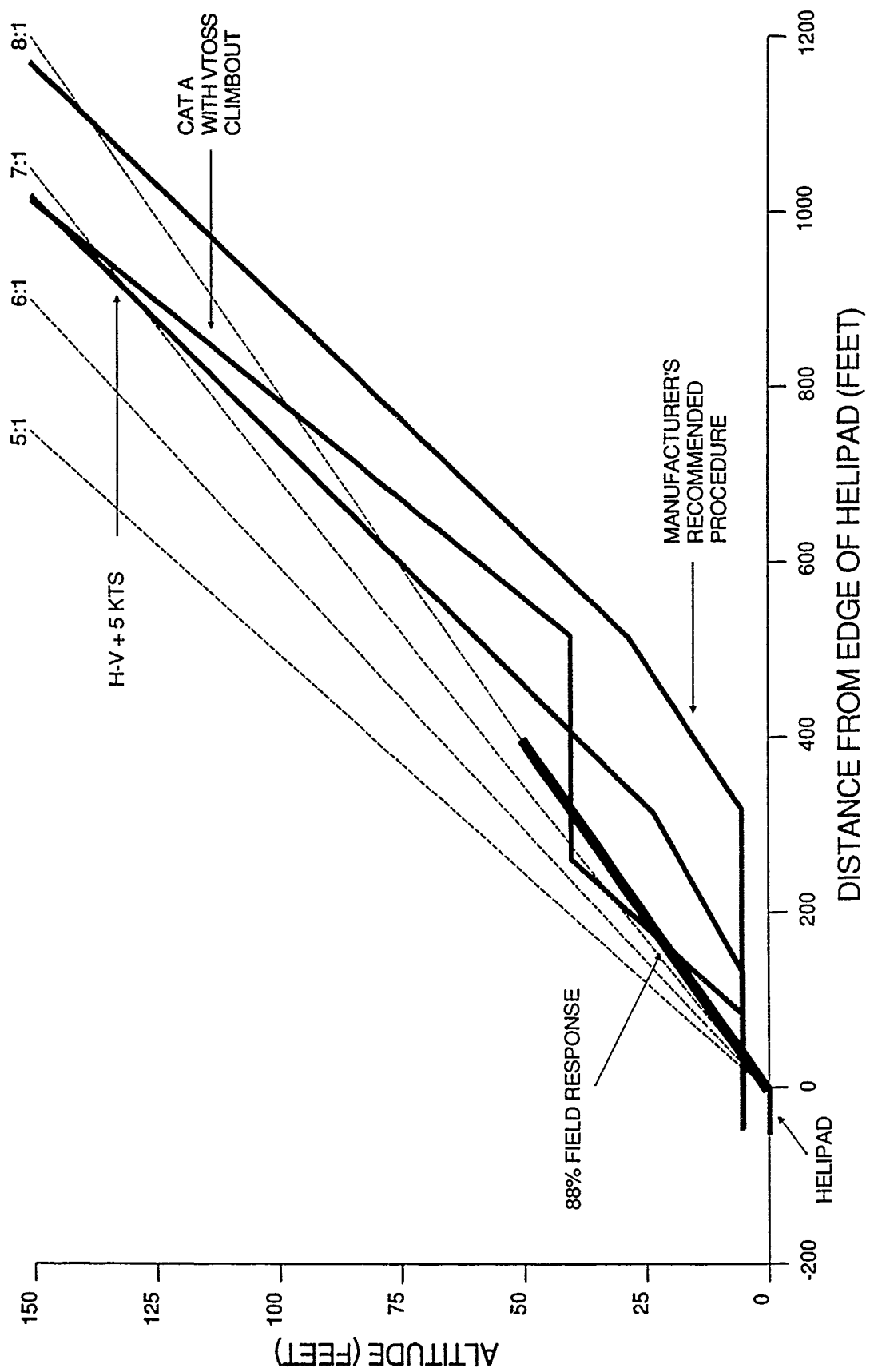


FIGURE C-2 S 76A DEPARTURE PROFILES MAX. G.W., SEA LEVEL, HOT DAY

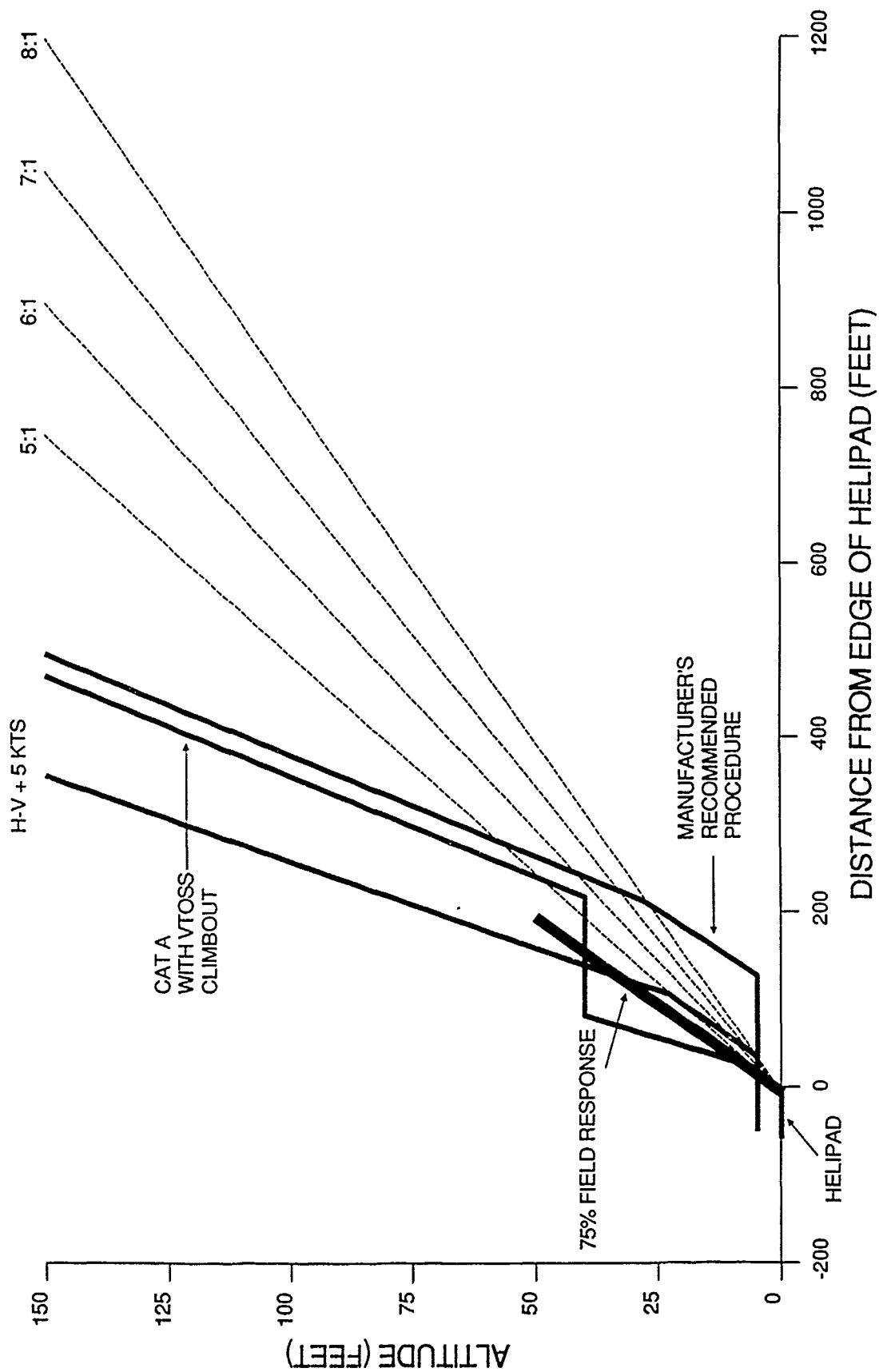


FIGURE C-3 S 76A DEPARTURE PROFILES 85% MAX. G.W., SEA LEVEL, STANDARD DAY

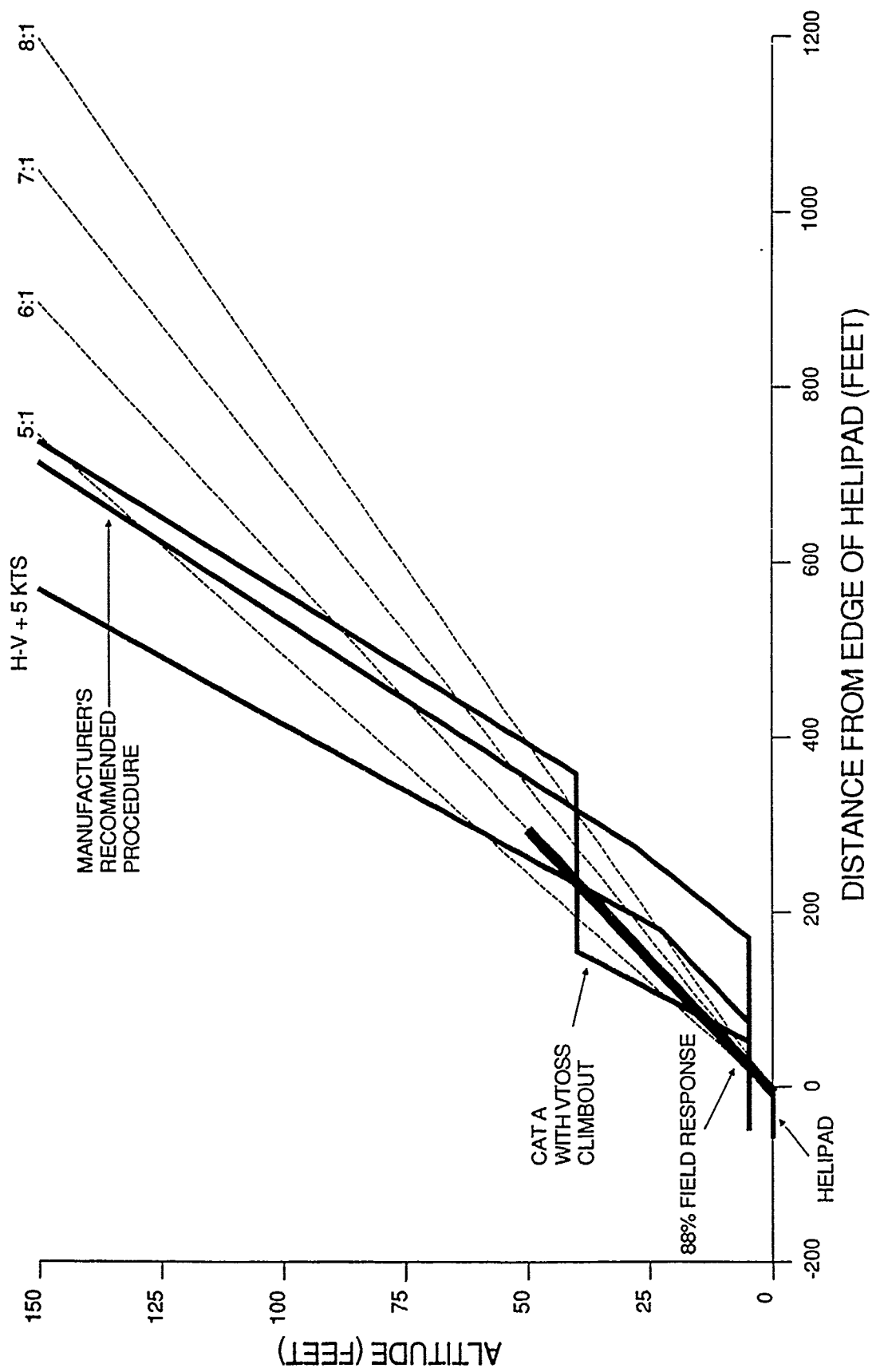


FIGURE C-4 S 76A DEPARTURE PROFILES 85% MAX. G.W., SEA LEVEL, HOT DAY

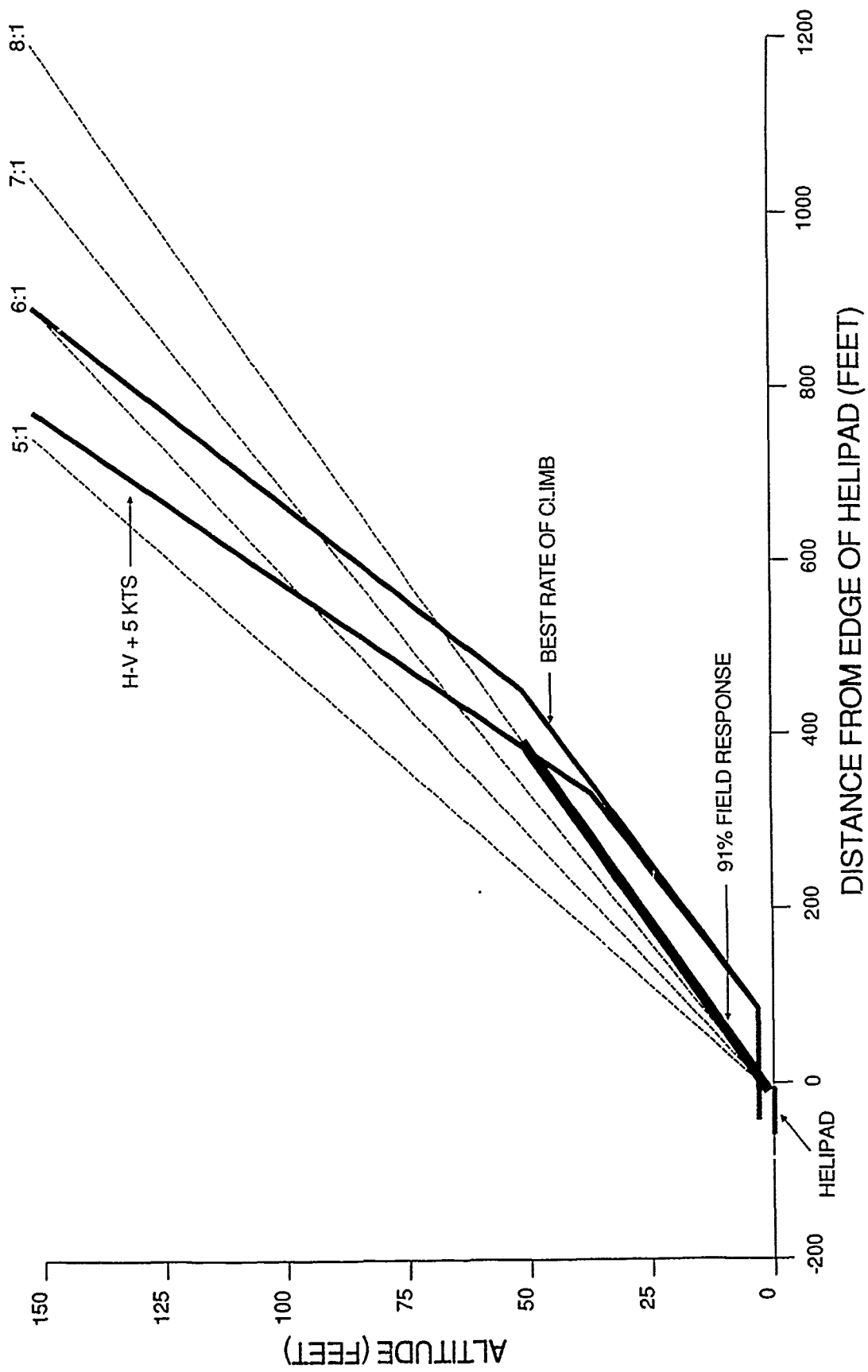


FIGURE C-5 B 206B III DEPARTURE PROFILES MAX. G.W., SEA LEVEL, STANDARD DAY

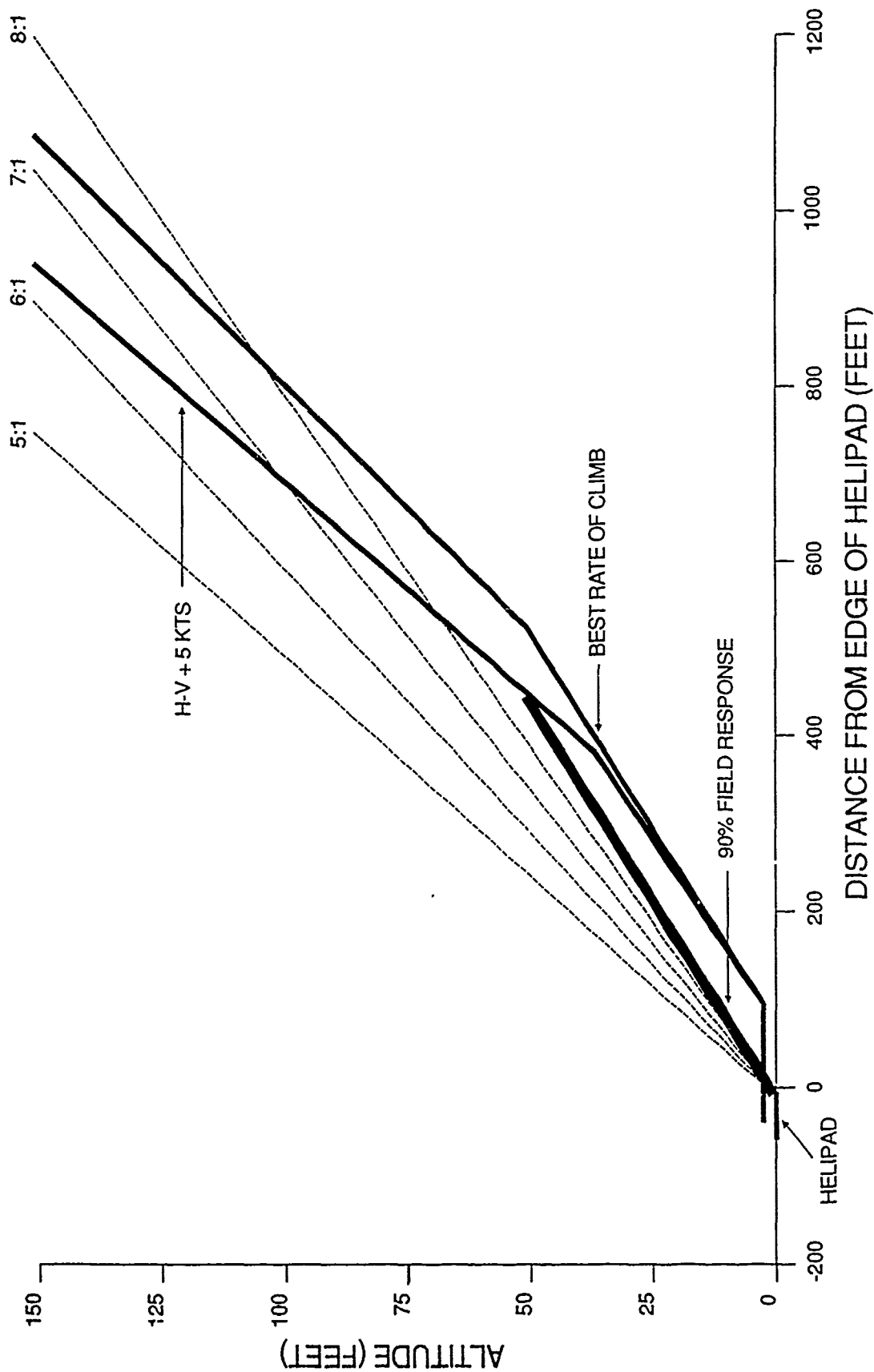


FIGURE C-6 B 206B III DEPARTURE PROFILES MAX. G.W., SEA LEVEL, HOT DAY

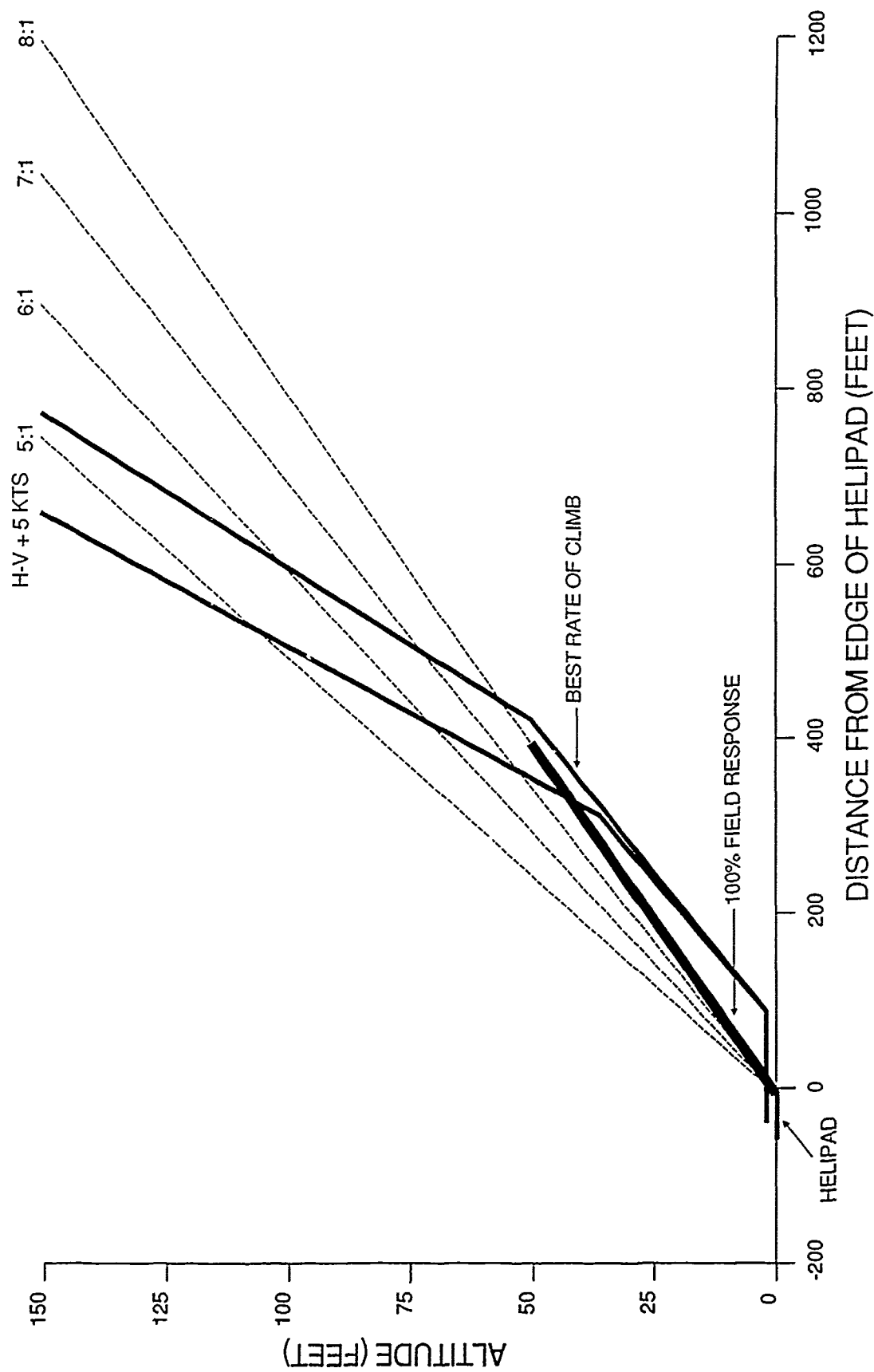


FIGURE C-7 B 206B III DEPARTURE PROFILES 85% MAX. G.W., SEA LEVEL, STANDARD DAY

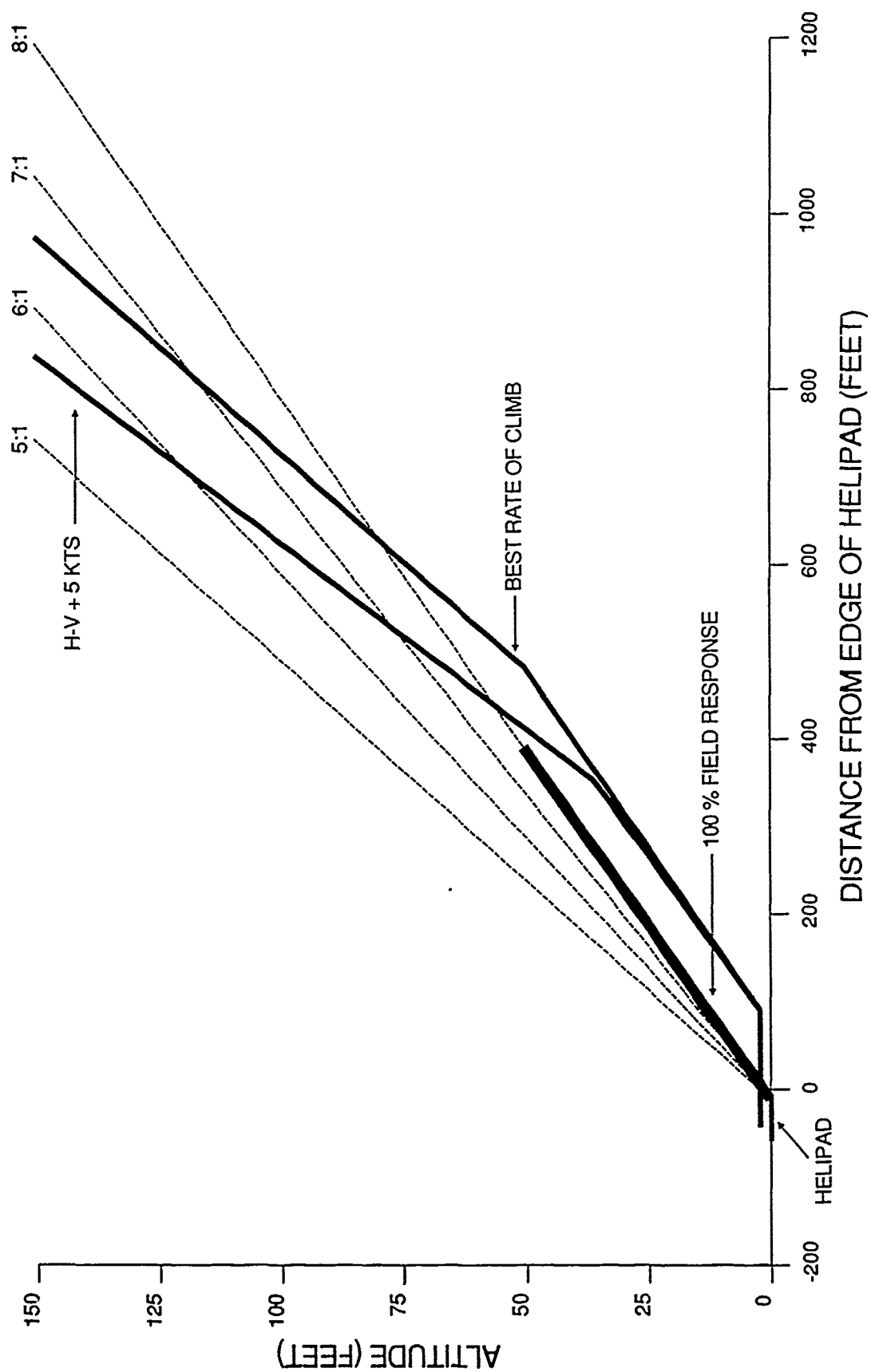


FIGURE C-8 B 206B III DEPARTURE PROFILES 85% MAX. G.W., SEA LEVEL, HOT DAY

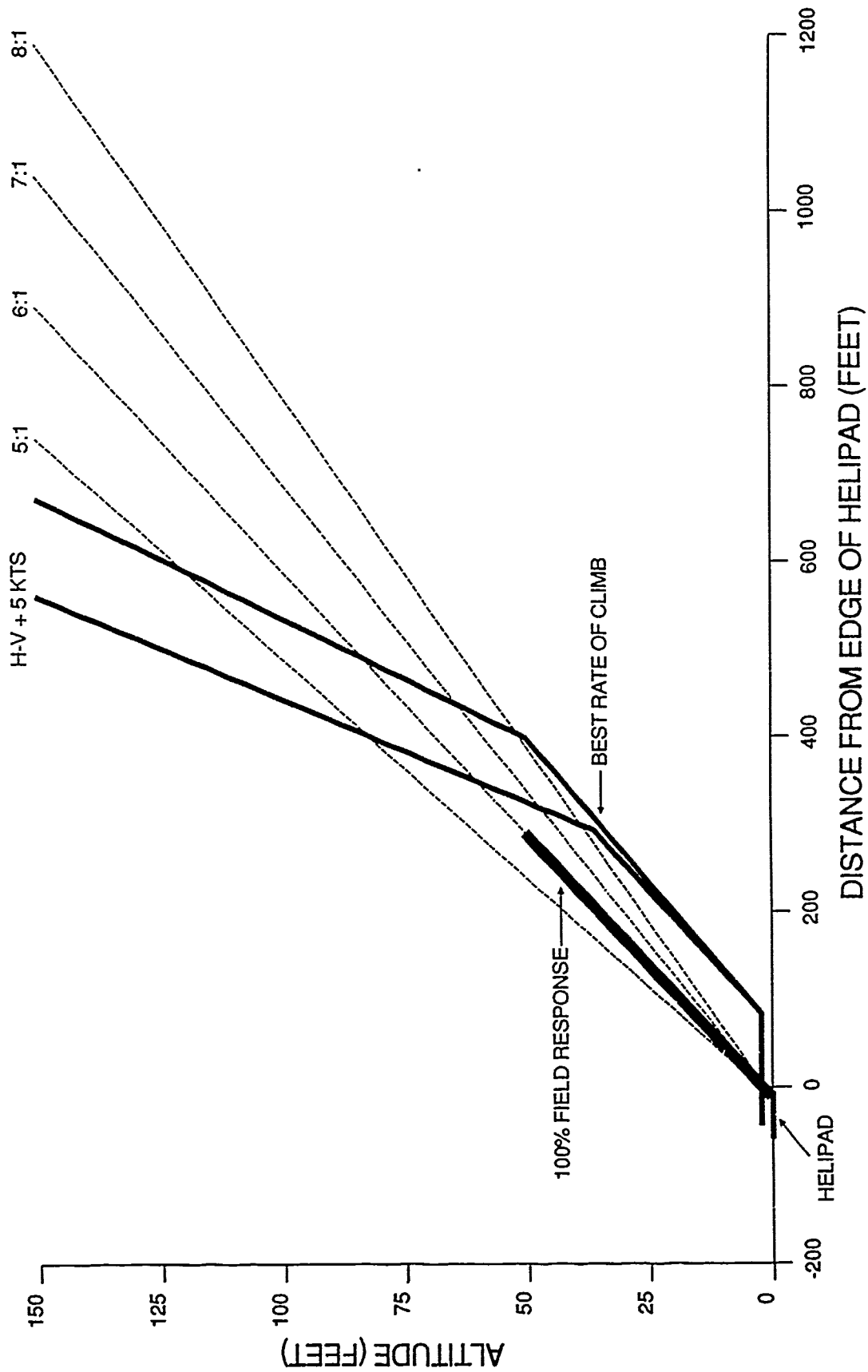


FIGURE C-9 B 206B III DEPARTURE PROFILES 70% MAX. G.W., SEA LEVEL STANDARD DAY

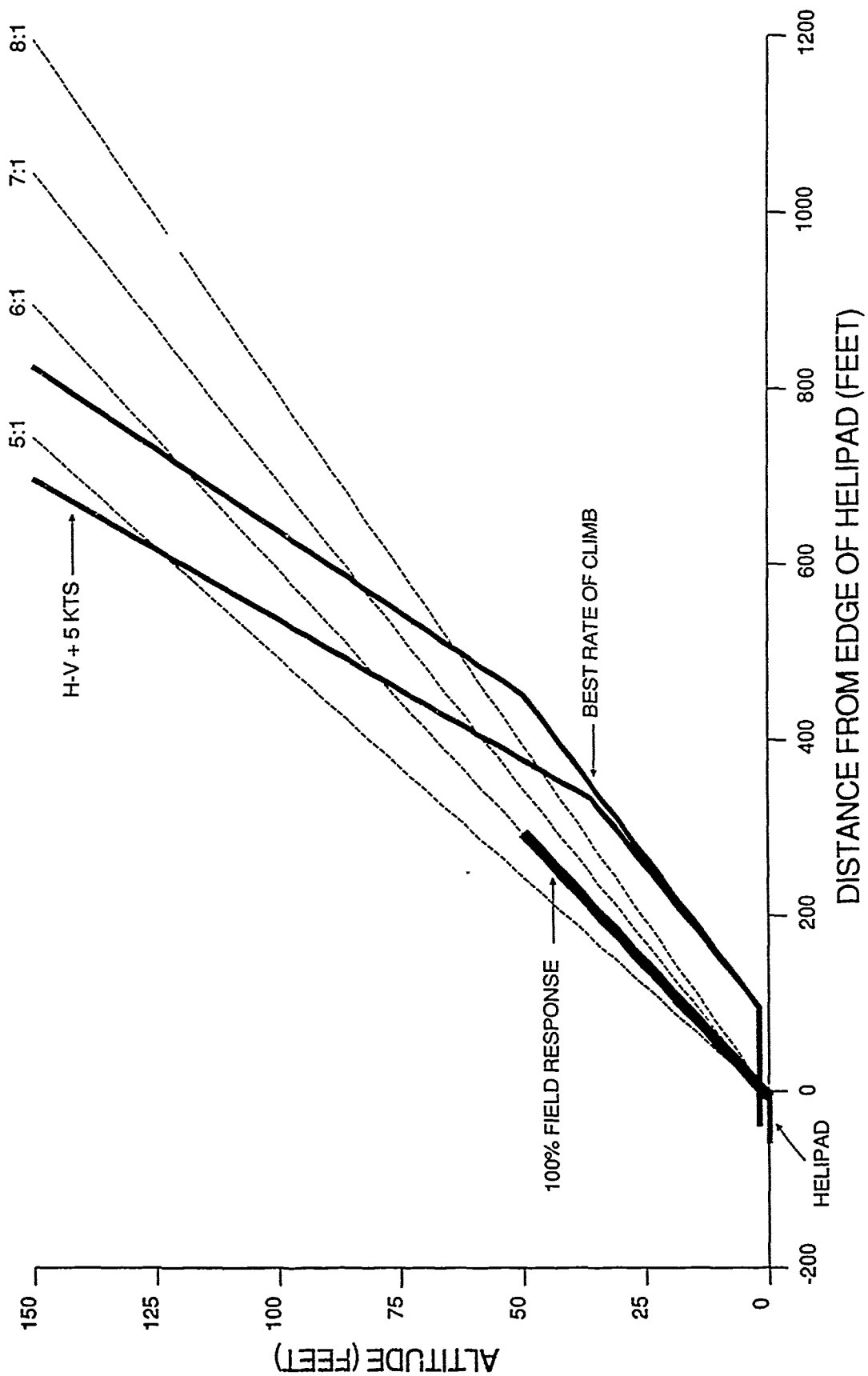


FIGURE C-10 B 206B III DEPARTURE PROFILES 70% MAX. G.W., SEA LEVEL, HOT DAY